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THE OUTLOOK FOR AN IMPROVEMENT IN BUSINESS.

By J. Edward Simmons,

President of the Fourth National Bank of New York.

AFTER a period of severe sickness it is generally expected that a patient will recover slowly. There is a stage in every disease which is called the turning-point, and I believe that, after the long siege of depression and general financial and commercial demoralization we have had in the United States, the turning-point has finally been reached. The reason why I believe this, is that, so far as I can judge, liquidation has ceased to a very great extent. The pressure of the panic forced men to liquidate, and the alarm created by that pressure has caused them to continue liquidation until they are now practically out of debt. There has rarely been a time when the outstanding obligations of merchants were so small as at present. This is exemplified by the large accumulation of money at the great money-centers and the scarcity of commercial paper for either sale or discount. The rate at which good borrowers can get money is unprecedentedly low, and the banks are overflowing with resources that they cannot invest.

The business of the whole country has been greatly curtailed by pending legislation at Washington, and until this legislation is completed we can hardly expect a *general* improvement in financial and commercial circles. The inflation of the currency, by the purchase of silver bullion for treasury notes convertible into gold, was, in my opinion, the principal cause of the panic. Since this process has been in existence the accumulation of silver bullion by the government has been enormous, and at present prices the loss to the government would be, through the sale of all the silver it has purchased under the Sherman act, more than $100,000,000. And yet, with this immense loss staring us in the face, many of our legislators at Washington favor the

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continuance of inflation by urging the coinage of the seigniorage, which will not add a farthing to the price of silver or a dollar of value to any mining interest. Every one who has given the subject a moment's thought must know that each new dollar put into circulation makes more difficult the convertibility of the nearly $600,000,000 of silver the gold-reserve is already called upon to carry. The stoppage of silver purchases by the repeal of the Sherman act has given relief to the financiers of the whole country, and we now find that we are, for the first time in many years, upon a solid and substantial financial basis. Therefore, we must say that, as far as financial legislation is concerned, our condition has improved. Let us hope that no backward step will be taken.

Ever since the introduction of the Wilson bill all sorts of gloomy forebodings have been entertained by those who were to be directly or indirectly affected by the changes proposed therein. The Wilson bill, by an unprejudiced mind, can hardly be regarded as extreme, and now that the people are familiar with its prominent features less alarm is apparent. The passage of the bill is believed to be near at hand, and with the settlement of the tariff question the merchants will soon adjust themselves to the new conditions and business must necessarily drift back to its normal state.

This is beginning to be anticipated by some of our leading financiers, as reflected by the improvement in the prices of securities. The Stock Exchange is a good barometer of public opinion. Disaster is generally indicated by the fall of prices, and prosperity by an advance in Stock Exchange quotations. The market of late has moved up a little all along the line. This has been caused, not by any settlement of receiverships, but by the confidence which is returning to investors in the ultimate restoration of values and the resumption of business prosperity.

Six great trunk-line railroads are in the hands of receivers, beside many smaller railroads, representing nearly $2,000,000,000 of securities, upon most of which interest has been suspended temporarily. But the reorganization committees are all working under the favorable conditions of easy money, and it is fair to anticipate an early return of railroad properties to the owners. In the meantime, the public should bear in mind that these railroads are all in operation and are likely to continue to be until their obligations are adjusted and the receivers discharged. I confidently believe that no other great railroad lines are now in danger of embarrassment.

It is true that the railroads which have not been embarrassed show a heavy average decrease in gross earnings, but there has been a corresponding heavy decrease in operating expenses, as a result of which,

in some instances, the current reports show an actual increase in net earnings. This would indicate a comparatively healthful state of the financial condition of the railroads. Another favorable feature of the situation grows out of the economy which the railroads have been practising. Since the date of the Baring failure, in 1890, the railroads have been reducing expenditures—a fact well known to those in the business of selling supplies to the railroads—and since the panic of last summer they have been forced to the very limits of the most rigid economy. It follows of necessity, therefore, that they must soon be in the market again for supplies; and such of them as are sufficiently strong financially are already reënforcing their equipment because of the exceptionally low prices now prevailing. Steel rails, for instance, are sold lower than ever before.

What is true of the railroads is true, to a greater or lesser degree, of the people. The demoralization caused by the panic has resulted in a spirit of economy that seems to have taken possession of every one. The rich man, although abundantly able to satisfy his desires, is reluctant to spend money, unless absolutely necessary, because of the prevailing distress. When 65,000,000 people retrench, the benefits that accrue from frugality must sooner or later be felt. Upon every hand there has been a great curtailment of production, but consumption and wear and tear have been going on all the time; and it is fair to presume that stocks of goods are rapidly decreasing and that it will not be long before the demand in all directions will be greater than the supply.

There was no fall trade last year, and the delay in legislation at Washington has killed the spring trade. The people are now anxiously looking forward to the crop period; and if the harvest is up to the average and we have a good foreign demand, as it is fair to think that we will have under existing low prices, the entire purchasing power of all our crops for this year will come against a greatly diminished supply in each and every branch of manufacture. With a people so easily stimulated, so ambitious, and so enterprising as Americans are proverbially known to be the world over, it must be apparent to any thoughtful mind that the stimulation which the marketing of the crops will produce throughout all lines of industry and commerce must restore confidence with a swing; and as a result we may reasonably look for a speedier revival next fall than a long period of depression under other circumstances would permit us to hope for.

We are having no trouble from a lack of money. We have to-day a larger circulation per capita than any other nation in the world, except France. We have about $25 per capita, while France has somewhere in the neighborhood of $45; but our advantage over the French

people is that while they have but few banks, we have banks everywhere, and the great bulk of our business is done by checks and drafts rather than by actual payments of cash money. Ninety per cent. of all the business of this country is done by checks and drafts, which are the real currency of commerce. The fact that our existing currency is amply sufficient for every possible demand in the near future is shown in the enormous accumulations of idle money in every money-center throughout the United States. There is as much money in the country as there ever was. The only loss that we have sustained in money has been represented by the outflow of gold to Europe. That has been more than offset by the outflow of silver certificates and treasury notes from our treasury department, together with the issue of national-bank notes, so that, as far as our currency is concerned, we are still upon an inflated basis, but we have, I hope, wisely stopped inflating.

In this connection there must be taken into account the immense increase of wealth in this country. All the statistical proof is to the effect that the accumulated wealth of the civilized world has actually doubled in the past generation, and the wealth of the United States has shown more than a proportionate increase. People who look back at the panic of 1873 and say that it will take years to recover, overlook the fact that we have an enormous surplus of wealth that did not exist in 1873, and that the owners of this accumulated wealth are ready and eager to embark it in profitable enterprises.

The United States offers the most tempting field for investment of any country in the world. The rate of interest paid here is larger, and the security offered is better. European money seeking investment, including the proceeds of securities that have been sent to this country and sold because of the fear of foreign capitalists that we were going to a silver basis, and that unless they obtained gold while gold was obtainable they would be obliged to sell their securities and take payment in a depreciated currency—a large part of that money will certainly seek reinvestment here because the United States has firmly placed itself upon a gold-paying basis.

This investment demand from abroad, together with the large accumulation in this country of cash seeking investment, will ultimately cause a reëstablishment of values, and will foster enterprise and stimulate trade. Indeed, we may confidently look for a return of that period when English capital will have representatives in this country for the special purpose of making investments, exactly as was the case for the few years preceding the panic.

There is a point in the situation that is especially encouraging, namely, that with all the decline that has taken place in securities, in

manufactured goods, and in everything else produced, there has been little decline in the price of labor. Labor, with few exceptions, commands as high a price as it ever commanded; and, in spite of the vast number of people said to be unemployed, the employed are willing to strike in case wages are reduced. This shows that the workers are not as poor as some of the newspapers have represented them. It also shows that they are still receiving good wages and are still buying in the market,—that greatest of all markets, our home market. In other words, to my mind, as I have studied this question, one of the most striking evidences of declining prosperity is the tendency of wages to decline and thus reduce the purchasing power of the wage-earner, just as the decline in the price of wheat reduces the purchasing power of the farmer.

Again, with all the falling-off of business, there has not been a corresponding falling-off in expenses as far as rents are concerned. There has been very little concession upon the part of the lessor to the lessee. Real estate in New York has held up remarkably well, except in unfavored quarters of the city. The decline in real estate that has been predicted is not likely to come at all, with the reëstablishment of confidence and the renewal of business activity. Real estate is the last thing to go down. When a man feels that he cannot continue in his store unless he gets a reduction of rent, then the landlord may make a concession of rent. But the value of improved property is estimated upon what it yields; and if lower rentals are obtained, of course the valuation placed upon the property must be less. The tenacity with which real estate has maintained its value may be accounted for in part by the general disturbance of confidence in corporate securities and the disposition of investors to put their money in real estate, where they can see it and control it without the aid of a board of directors. Altogether, the fact that no great decline in real-estate values has yet occurred, shows that the ravages of the panic have not been as far-reaching as many gloomily-disposed persons have thought. Furthermore, it shows that our people, because of the long period of prosperity in business circles which preceded the panic, were better fortified than ever before to meet the great decline that has taken place in mercantile and in security values.

Improvement appears on every side. The clouds have lifted. The skies have cleared, and there is warrant for confidence. The business turning-point has finally been reached.

E. F. Fish, Engr. N. Y.

SOUTH AMERICAN RAILROAD DEVELOPMENT.

By Courtenay DeKalb.

THE development of railroad communication in South America has taken place under conditions so dissimilar to those obtaining elsewhere in the world that the results have been widely different, both to the countries concerned and to the railroad corporations themselves. The first incentive to that continental expansion of railroad systems which we have witnessed in the United States was the wealth to be derived from colonizing immense grants of virgin land. Our roads grew as a necessary adjunct to a gigantic pioneering movement. They have changed unpeopled deserts into great and flourishing states, and they stand to-day in such a legal relation to the commonwealth as insures a steady improvement of their facilities for handling a growing commerce. In South America numerous political subdivisions have restricted the growth of highways within comparatively narrow territorial limits, and opposed that free expansion to which the physical peculiarities of the continent might otherwise have led. Thus we find isolated groups of roads, national systems instead of great trunk-lines, and in general a lack of diversity in the products of the territory served by each system. This results in a scanty interchange of domestic commodities and causes great inequalities in the movement of freight at various seasons of the year. Moreover, the South American railroads have not furthered colonization on a scale comparable in any degree to what has taken place in North America, and such a result has not been relied upon to produce any immediate augmentation of traffic. An existing commerce of some magnitude or mines certain to yield a fair amount of freight have constituted the controlling motives in most instances.

In many cases, however, there has been no reason in the nature of things for the construction of railroads in South America—no important commerce seeking an outlet, no mines to be developed, nothing, in short, but a local ambition to emulate the progress of more favored regions; but the prospect of returns from a government guarantee of interest has induced capital to enter almost as readily into such unworthy enterprises as into those where profits could be foreseen from actual traffic receipts. Financial and political difficulties have very naturally followed, and indeed the system of government guarantees has throughout proved a source of discord and trouble,

and has reacted upon the management of the railroads in such wise as to lessen their usefulness. The evil was, however, in a measure forced upon South America. Various circumstances combined to render the Latin continent unattractive to emigrants and to capitalists, so that it became necessary to hold out special inducements for the building of railroads. This might have led to no ill results if the proper functions of such highways in the promotion of national growth had been understood, but the concentration of the bulk of population near the seacoast, in a sort of fringe around the continent, caused these countries to take a narrow view of the situation. Attempting to develop the resources of a large number of these coast communities, they sanctioned the construction of numerous short lines running a few miles into the interior from separate ports, so that interstate commerce was not promoted, and, instead of leading to industrial progress, they merely increased the quantities of the same class of products which had been shipped before.

This is particularly true of Brazil, where, out of eighty-four separate lines, representing a total of about 6000 miles, not more than twelve lines, comprising about 1700 miles of track, are earning their operating expenses. On the majority of the Brazilian roads the expenses are fully a fourth more than the gross receipts. The government has guaranteed interest on a capitalization of $135,000,000 and has already paid in such guarantees more than $80,000,000, while the maintenance of this expensive luxury drains from her vaults every year no less than $9,000,000. Thus there has been a total outlay of foreign capital and interest paid by the state on unproductive roads reaching the enormous sum of $215,000,000,—enough to have constructed a great system of roads connecting every state on her Atlantic coast, even allowing so liberal a cost as $50,000 a mile. The cost of the guaranteed roads has frequently exceeded this amount, but it is noticeable that the unguaranteed private lines have frequently cost no more than $35,000 a mile. That such a great Brazilian trunk-line would share a better fate than the present isolated roads is a warrantable deduction from the fact that in the state of São Paulo, south of Rio de Janeiro, where a group of railroads aggregating 1200 miles in length is connected into a system ramifying far into the interior, every line is paying expenses, and some of them, after meeting all fixed charges, are paying dividends of 14 per cent. on their common stock. Furthermore, the Central (or Dom Pedro Segundo) railroad, which connects the São Paulo system with Rio de Janeiro, is earning a net profit of more than $2,000,000 per year on its 460 miles of track. It is through this region of Brazil that we find the greatest diversity of occupations; it is here that we find mechanics and manufacturers as well

as agriculturists and traders. Within the last few years the railroads of Rio Grande do Sul have also grown into an extensive system, reaching across to Uruguay in the southwest, and the same phenomenon of prosperity is being repeated here; factories for making cotton and woolen goods, candles, soap, combs, buttons, and articles of leather have been established, a larger acreage has been brought under cultivation, and the railroads are at last beginning to earn their guarantees.

It is fortunate for Argentine that she inherited from the colonial era widely-separated centers of population. In the east were the Platine settlements of Buenos Ayres and Santa Fé. Far in the west, beyond the pampas, lay Mendoza; huddling in the foothills of the Andes in the northwest were Tucuman and Catamarca; while midway, where the Sierra de Cordoba breaks the broad expanse of plain, had grown the colonies of Cordoba and San Luis. The products of these various districts also differ greatly. In the north prevailed a semi-tropic climate, while farther south conditions favored cattle-raising and the culture of wheat and other cereals. Thus it happened that the Argentine railroads extended over large areas, and threw off branches at many points, serving a widely-diffused population. Trunk-lines and systems of roads became the rule, and rapid development took place in all directions. The first section of the Buenos Ayres Great Southern railway was opened in 1864. Others soon followed, and by 1880 there were 2473 miles in operation. The stimulus of improved transportation facilities now became felt more strongly, and line after line was built, until, by the end of 1893, the Argentine railroad board reported a total service of 8111 miles, representing an invested capital of $390,000,000, yielding a gross annual revenue of $24,000,000. The average of invested capital per mile is accordingly $48,082, with gross returns averaging $2958 per mile. It is interesting to compare these figures with similar statistics of railroads in the United States, where a total of 170,601 miles of track represents an absorption of $11,110,335,276, or $65,124 per mile, yielding a gross revenue of $1,138,024,459, or $6670 per mile.* The gross receipts in the United States amount to 10 per cent. on the invested capital, whereas in Argentine the receipts are 6 per cent. on the capital. It is not easy to make a fair comparison of operating expenses in the two countries, owing to the absence of complete data, but on nine representative Argentine roads, aggregating 4330 miles of track, the expenses in 1892 consumed 71 per cent. of the gross receipts, while the average on all railroads in the United States for 1891 amounted to 68.83 per cent.

The influence of this great system of roads has been to transform Argentine in thirty years from a pastoral country, producing only

* These figures are from Poor's Railroad Manual for 1892.

hides and tallow and wool for export, into an agricultural and manufacturing country ranking among the great producers of the world. To be more specific, her sheep-ranches yield a gross annual product of $77,000,000, her cattle-ranches $39,000,000, her farms $86,000,000, her vineyards $8,000,000, and her miscellaneous industries, including manufactures, $183,000,000. The transition from cattle- and sheep-raising to farming and general industries still goes on apace, as may be illustrated by the increase in tonnage carried by the Buenos Ayres Western railway, from 315,000 tons in 1892 to 493,000 tons in 1893, the gain being due entirely to the substitution of wheat-farming for sheep-breeding. The Argentine railroads, with the exception of that small mileage lying east of the Rio Paraguay, constitute a continuous system radiating from Buenos Ayres throughout the populous portion of the republic, connecting with Bahia Blanca, 445 miles to the southward, with Jujuy, close to the Bolivian frontier, nearly 1000 miles in the northwest, and with Mendoza, at the base of the Andes, 649 miles to the westward.

In Chile new conditions are found. The country is narrow, varying from 40 to 200 miles in width, and is intersected by numerous valleys, so that the natural tendency has been to bring the products of the Chilean mines and farms by the shortest routes to the sea. Yet, in spite of circumstances which clearly indicated numerous port-feeding railroads as a first necessity, the Chileans, with commendable wisdom, have encouraged the construction of a north-and-south trunk-line which parallels the Pacific coast for a distance of 350 miles. This has materially promoted her rapid growth as an agricultural and manufacturing country. Technical industries have reached a higher development in Chile than in any other portion of South America, and the urban population has increased to about 80 per cent. of the total enumeration for the republic. The government is now striving to arrest this tendency to concentration of the people in cities, and to this end is proposing changes in the railroad law which are expected to bring into existence a large number of branch lines radiating through the rural districts, which, by cheapening freights, will improve the condition of the farmers. Out of a total of 1846 miles of railroad in Chile, the government owns and operates 686 miles. Complete returns from the private lines are not available, but full statistics concerning the state roads show that they represented, up to December 31, 1891, a gross expenditure of $58,752,787, or $85,674 per mile. The receipts for 1891 were $10,151,196, of which the expenses consumed 82 per cent., leaving a net revenue of only $1,827,216, or $2687 per mile.

The Chileans confess that state management of railroads has not

proved economical, and a project is on foot for leasing all the government roads to private corporations. As a rule the railroads of this republic have been costly, and the traffic fluctuating, so that the returns have never been continuously satisfactory. It is thought that a better balance of commerce will be established by a continuation of the present central system southward into Valdivia, where an immense timber and agricultural region awaits development. The effect of the trans-andine road when completed will also be important, as Chile will then be brought into reciprocal relations with Argentine. There remain only forty-three miles to be built to afford through communication between Valparaiso and Buenos Ayres. Twenty-two miles, of which nine miles will consist of tunnels, are on the Chilean side. Of the remaining twenty-one miles, on the Argentine side, 2⅝ will be tunnel work. The Chilean government will increase its guarantee of interest to 5 per cent. on an estimated cost of $7,000,000 necessary to complete the western section of the line, and the Argentine section will progress *pari passu* until the rails meet on the summit level. Tickets are now sold at $60 between Buenos Ayres and Valparaiso, and at $200 between London and Valparaiso via this route, the gap between Punta de las Vacas in Argentine and Salto del Soldado in Chile being traversed on mules, although a stage-coach service is promised by June, 1894. The distance between the Argentine capital and the great Chilean port is 882 miles, and the present intention is to charge at the rate of $87.27 per ton for freight between the two points. This of course will preclude the shipment of through freight, but there is a large commerce crossing the Andes between the two republics, and such a rate of 9.89 cents per ton per mile will be a great boon, and will certainly stimulate an exchange of products.

Three railways are in operation already across the lofty western cordillera of the Andes. The first in point of time was the Southern Railway of Peru, connecting the port of Mollendo with Puno, on Lake Titicaca, at an elevation of 12,500 feet above the sea, built by American engineers and opened to traffic in 1874. More recently the Antofagasta and Bolivian railway, starting from the Chilean port of Antofagasta, has pushed across the Andes and onward through the great Bolivian table-land to Oruro, only 139 miles from La Paz, the capital of the republic. The total length of this line is 574 miles, and it is now being extended to La Paz, while a branch from Uyuni to the famous silver region of Potosí, a distance of sixty miles, is under survey. It was built primarily to serve the needs of the Huanchaca of Bolivia Silver Mines Company and was very cheaply constructed, the gage being thirty inches and the track being laid with 36-pound steel rails. A very considerable commerce, however, has taken advantage of the

facilities it offers, the traffic movement in 1892 having been 416,166 tons of freight and 21,741 passengers, yielding a gross income of $1,235,316, or $2152 per mile. The operating expenses amounted to $804,847, leaving a net income of $430,469.

The Peruvian group of railroads consists of a number of completely-isolated lines, aggregating 1127 miles. The Southern railway, by means of steamboat connection across Lake Titicaca, attracts considerable Bolivian traffic, and its northern branch to Sicuani, which is being extended on to Cuzco, will ultimately form part of a system traversing the great central plateau.

During 1893 the famous Lima and Oroya (Central) railroad, with which Henry Meiggs, of the United States, was at one time connected, was completed as far as Oroya across the western chain of the Andes. The summit level of this remarkable road is 15,645 feet above the level of the sea, and throughout its whole length many difficulties of construction have been overcome by the genius of American engineers. It has now reached the silver-producing region and will be pushed on to the world-famous mines of Cerro de Pasco, but this is only a small part of its value to Peru. It has broken the great barrier which lay between the fertile, well-watered *montaña* and the arid western coast. From this time we may expect a steady growth of agriculture which will render Peru independent of foreign markets for her staple food supplies. Consequently we may anticipate the expansion of a railroad system throughout the *montaña*, which will bring to the Central railroad an enormous traffic.

With a few exceptions all the Peruvian roads are under the direct management of the Peruvian Corporation, Limited,—which has assumed the entire national debt of the republic. When they were handed over by the state, in 1889, they were in a wretchedly dismantled condition,—the result of the Chilean invasion and the subsequent poverty of the country. Most of them were being operated at a loss, due to poor equipment, poorer management, and official corruption. Their tracks have now been repaired, their rolling-stock improved and increased, and, under prudent management, they returned a net income in the fiscal year ending June 30, 1893, of $487,094. This is only the beginning of a prosperity which will equal if not surpass that of the most productive roads in South America.

Little need be said of the railroads in actual operation in Ecuador and Colombia, since they serve, not to control and create commerce, but as mere adjuncts to water and mule transportation. Venezuela has scarcely passed beyond this condition, although the Central railway, from Carácas toward the east, and the Tucacas-Barquisimeto line bid fair to aid largely in the development of the country.

Returning to the south, it must be noted that Uruguay, a state only nine times as large as Massachusetts, has an excellent system of about 1000 miles, penetrating the country in every direction,—from Montevideo to the Rio Uruguay on the west, and to Brazil on the north. Paraguay has 155 miles of railroad, which are being operated at a trifling profit.

Taking a comprehensive view of the railroad situation in South America, the most notable and instructive circumstance is that isolated, port-feeding lines do not pay and do not develop the resources of the country, while *systems* of roads do pay, and develop commerce, and stimulate diversity of occupations on the part of the people. There are of course some important exceptions, such as the Nitrate railways of Chile, whose returns average about $7000 per mile per year, and whose operating expenses are less than 35 per cent. of the receipts, and the La Guayra and Carácas railway, whose receipts are $20,000 per mile per year, with operating expenses at 74 per cent., but these anomalies are explained by peculiar local conditions. An exception may be found in the case of systems, also, where the Uruguayan railroads, as a group, are barely paying expenses, although some of these are doing well and all show a steady increase of traffic. The next notable circumstance is that railroads enjoying a government guarantee of interest do not pay so well as private unguaranteed lines. The cause of this would seem to be due in part to careless management, resulting from the indifference of stockholders who are content with their guarantee, and look askance upon outlays for improvements, the returns from which are more or less problematical. The interference of government is also a potent factor in reducing their profitableness, since modifications of tariffs and wages can be made only with the consent of officials, which is often difficult to obtain and always involves delays, so that the companies cannot promptly meet emergencies when these arise. Furthermore, such railroads almost invariably are bound by contract to revert to the government, after periods varying usually from forty to sixty years. This naturally discourages heavy expenditures upon permanent way and rolling-stock, so that the efficiency of the road is almost always limited by these unfortunate conditions. A system of state aid to encourage railroad-building, which seems to promise better results, has been adopted in Colombia, whereby interest-bearing bonds, receivable for customs, are issued by the government to railroad companies in certain sums for every mile of track actually constructed. A third circumstance is that roads owned and operated by the state are never so profitable as private lines handling an equal amount of traffic, and without exception there is an abnormal deterioration of track and equipment under state management.

In round numbers, there are about 19,000 miles of railroad in South America, of which more than 75 per cent. yield a net profit above operating expenses. There is consequently no little encouragement for the construction of new lines, and, while the reckless rush for concessions has ceased, there are many projects under consideration which promise to serve a useful purpose. In Brazil the progressive Mogyana Railroad Company, a Brazilian corporation, is pushing its line northward and westward from the state of São Paulo toward Goyaz,—a rich but isolated state which this road seems destined to control. This may lead in time to a trans-Brazilian line reaching Cuyaba, near the Bolivian frontier. There is also a project for extending the São Paulo system across to Paraguay, which has evident merit, and which probably will be accomplished if colonization continues in that republic. In Argentine the Corrientes line, east of the Rio Paraguay, contemplates making through connection between the Uruguayan and Paraguayan roads, which will give a powerful impulse to the development of this whole region from Asuncion to Montevideo. Mr. Frank Parish, one of the greatest Argentine railroad magnates, is now planning a network of roads, aggregating 770 miles in length, intended to develop the valleys of the Rio Colorado and the Rio Negro in that republic, making them tributary to the Argentine Great Western railroad. Renewed efforts are being made to extend the National Central Northern railway from Jujuy to Potosí, in Bolivia, a distance of 300 miles, where it will connect with the branch of the Antofagasta and Bolivia railroad now being located. Thus will be established a second transcontinental route, which will shortly have an alternative outlet to the Pacific coast by the Southern Railway of Peru, there being two projects on foot for a connection between Puno and La Paz, and the construction of the Antofagasta and Bolivia road being now in progress between La Paz and Oruro.

The purpose of the Chilean government to promote the further paralleling of the coast toward the south has been previously mentioned. The Central Railroad of Peru, according to the contract of the Peruvian Corporation, Limited, must soon be completed to navigable water on one of the Amazonian tributaries. The Pacasmayo and Magdalena railroad is to be continued to Caxamarca, the Chimboté line will soon develop the mineral and agricultural resources of the remarkable valley behind it, and the project for extending the Payta and Piura road to navigable water on the Amazon is again receiving deserved attention. In Ecuador the line from Guayaquil to Chimbo is to be built across the cordillera to Riobamba, and thence to Quito. The government, taught by the failure of previous contracts, will insist upon ample guarantees of good faith in the fulfillment of the new contract.

The railroad development of Colombia is just beginning. An American company is building a line from Buenaventura on the Pacific to Cali in the Cauca valley, which will thence extend southward to Popayá. It is a most important line, contemplating a development of one of the richest regions in South America. The future growth of railroad systems in Colombia must be chiefly north and south, following the trend of its great valleys, and the Cauca railroad will be one of the most important parts of this system. The Antioquia railroad, starting from Puerto Berrio, on the Rio Magdelena, is also under construction and will ultimately extend into the upper Cauca valley. The Cartagena and Magdalena railroad, which is intended to divert the traffic of the Magdalena through the port of Cartagena, and which will be in operation by June 1, 1894, is another important North American enterprise wisely conceived, and destined to promote the growth of a great north-and-south trunk-line terminating at this magnificent land-locked harbor.

It is hardly necessary to mention those projects which rest so manifestly on a romantic basis that capital will never hazard so much as may be necessary to make preliminary surveys, such as the Pernambuco (Brazil) to Valparaiso (Chile) grand trunk-line, the Buenaventura to Bogotá (Colombia) transandine road, and the Araguaya (Brazil) mixed rail- and water- route from Goyaz to Pará. The proposed military road from central Chile across the deserts to the northern provinces could find no warrant on any but a military basis for its construction.

There are some plain destinies, however, which we are certain to see worked out, slowly it may be, and it may be as swiftly as the mountain-bastioned table-land of Bolivia has been rendered accessible to the world. Brazil must have a coastwise trunk-line, and a second running east and west to the valley of the Paraguay. It will not be long before the separate systems of Argentine, Chile, Bolivia, and Peru will be connected into one. Finally, the growth of the Colombian and Venezuelan roads will create a system developing the Caribbean-coast region and extending southward into Ecuador and Peru.

One serious disadvantage which will be felt more keenly as the present systems form connections with each other is the bewildering diversity of gage prevailing, not only in different parts of the continent, but throughout each separate state. In Argentine are gages of 5′6″, 5′5″, 4′8½″, 3′, and 1 meter. In Brazil conditions are still worse, the variety being 5′3″, 3′6″, 3′1¼″, 2′11½″, 1 meter, and .95 meter. As an example of the obstacles which traffic will encounter from this cause, the connection from Argentine through Bolivia to Peru will be accomplished through the National Central Northern 1-meter gage, the

Antofagasta and Bolivia 30-inch gage, and the Southern Railway of Peru 4′8½″ gage. This evil is common to all new countries, but South America seems to be singularly afflicted in this particular. There can be no doubt that any sort of a tramway would be a hundred per cent. better than a mule, and this consideration may warrant the construction of many flimsy, narrow roadways, but where an expensive permanent way is contemplated future railroad-builders would do well to secure legislative action fixing a standard gage, to which all subsequent mileage in that state must conform, and the sooner an international agreement on this question is reached among the South American republics the swifter and more steady will be their development.

The river systems of South America have hitherto played an inferior part in the acceleration of commercial progress, but they will become factors of the greatest value upon the extension of railroad systems. In the north, the Orinoco and its giant tributary, the Rio Meta, afford 900 miles of east-and-west navigation, extending to within 125 miles of Bogotá. At a distance of eighty miles to the westward of Bogotá is the Rio Magdalena, navigable southward from the Caribbean sea for 600 miles. Here is a great triangular region, bounded by the Orinoco, the Magdalena, and the Caribbean, having an area of 1,000,000 square miles, no point in which is farther than 150 miles from water communication,—a circumstance which, combined with its wonderfully varied resources, will make this one of the most favored portions of the globe, with transportation charges so low as to encourage enormous production. The valley of the Paraguay, navigable 2400 miles northward into Brazil, with its floods sweeping past the great commercial center of Argentine, must exert a powerful influence upon the development of the heart of the southern continent. The function of the Amazon will apparently be less important. It cannot economically be paralleled by railroads. It will continue to serve as an outlet for certain products from the eastern portions of Bolivia, Peru, Ecuador, and Colombia, and, as these sections are traversed by railroads, it may regulate freights upon them to some extent. The Pacific ocean is the competitor which will cheapen freights and favor the growth of a railroad system on the western coast; the Rios Magdalena and Orinoco, with the Caribbean sea, constitute the guarantee of large prosperity for the northern portion of the continent; while the Rio Paraguay promises to be the scene of commercial activity rivaling that of Argentine and of São Paulo in Brazil, as soon as sluggish water transportation shall be supplemented by the facilities of railroads.

There are many reasons why American capital and American engineers should enter these promising fields. In the southern continent opportunities are afforded for the exercise of that rare ability which our peo-

ple have shown in opening up virgin lands. We have developed the most scientific and most economical railway practice in the world. This skill and knowledge brought to bear upon South America will soon fill the continent with the bustle of industrial activity, and create an ever-growing market for the surplus products of our labor.

Even to-day we might reach a richer harvest than we do. It is very generally recognized that American rolling-stock, on account of its lightness and strength, and its adaptability to curves of short radius, is superior to any other for use on the majority of the South American railroads. In consequence of this many British and European manufacturers advertise "American" equipment, modelled after patterns prevalent in the United States. When it is considered that in many cases the equipment is subject to government approval, and that the recommendation of American types is met usually by the substitution of foreign imitations, it is evident that an unworked field exists in South America for our manufacturers of cars and locomotives. But we cannot hope to sell largely to new countries while our capital stands aloof from the development of their resources. An order for merchandise is truly a "favor," as merchants say, but in the great balance of trade these "favors" are found to be reciprocal to a large extent. Invested capital can determine the commercial intercourse of nations, and, if we would insure our participation in the benefits of this growing southern commerce, we must aid in the expansion of routes of communication in South America wherever the visible traffic is sufficient to sustain them.

TRANSPORTATION BY WIRE-ROPE TRAMWAYS.

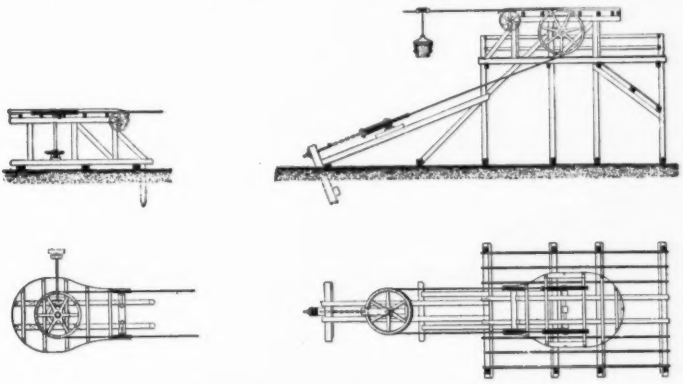
By William Hewitt.

THE application of wire rope to purposes of economical transportation, in the shape of aërial tramways, has opened up such wide possibilities in mining and other operations that some account of the different methods and of the progress made of late years in this peculiar branch of engineering can hardly fail to be of interest. The idea of conveying materials by means of suspended wire ropes is not by any means new, but has long been an attractive one, especially to miners and quarrymen, as it avoids the long and costly detours which, in most mining sections, would be necessary in any kind of surface road. At first glance it would seem to be a simple problem, but, like everything else in engineering lines, considerable thought and ingenuity have been expended in its development, and it was many years before this method of transportation could be depended on for anything but the lightest kind of service, and then only under favorable conditions.

The first instance of aërial transportation of which we have a record appeared in 1855, when Mr. Peter Cooper constructed a line at Ringwood, New Jersey, for carrying ore from the mines to the blast-furnace there. The line was operated by gravity (the fall being sufficient for this) and consisted of an endless $\frac{3}{8}$-inch wire rod, running over grooved sheaves and around large terminal wheels. To this rod were suspended a series of buckets by means of curved pendants or hangers, the tops of which were fashioned in the form of a gooseneck, in order to clear the flanges of the supporting sheaves. Wire rope at this time was unknown, or at least had not come into general use.

With the advent of wire rope, however, it was not long before its adaptability to aërial transportation was recognized. The first application of the kind appears to have been made by John A. Roebling, for transporting coils of wire in the construction of his suspension bridges. The pioneer in this direction, however, to whom most credit is due, is Charles Hodgson, of Richmond, England, who obtained letters patent in 1868 for "an improved means of an apparatus for transporting loads," in which he describes two modifications of his invention. In the first, which he designated as the "fixed-rope" system, the loads were suspended from trolleys or "running blocks," as he calls them, traversing a pair of stationary ropes, and propelled

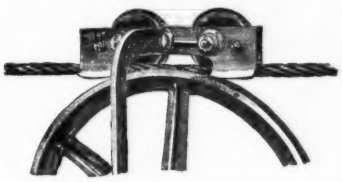
by means of an endless moving rope, to which these blocks were attached—a modification which has since been developed and perfected by Adolph Bleichert, to whose improvements we shall refer at length later on. The second modification, which he describes as the "single-rope" system, consisted simply of a single endless moving rope, serving to both support and convey the loads. Although the "fixed-rope" system was the first to be described in the patent referred to, and the first one to be experimented with, in the subsequent development



TERMINALS OF SINGLE MOVING-ROPE TRAMWAY.

of the invention it was abandoned, principally on account of the difficulty of getting suitable materials for the "running blocks," and all improvements were directed to the second or "single-rope" system, which is now the one commonly associated with Mr. Hodgson's name.

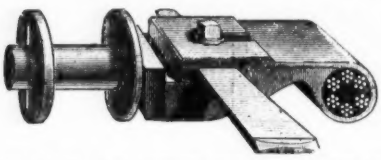
The "single-rope" system in its experimental stage was virtually the same in conception as that embodied in Mr. Cooper's tramway at Ringwood. The details may have been a little more carefully elaborated perhaps, but the only radical difference was in the employment of a wire rope in place of the traveling rod which Mr. Cooper used.



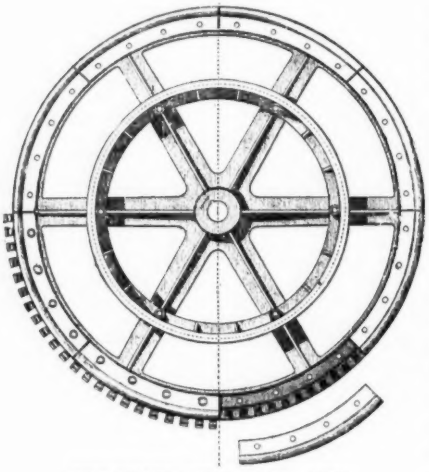
BOX-HEAD CARRIAGE FOR SINGLE-ROPE TRAMWAYS.

Mr. Hodgson succeeded in interesting Messrs. Bullivant & Co. in his invention, and a number of prominent Englishmen, among whom may be mentioned W. T. H. Carrington and E. G. Spilsbury. An experimental line was built on

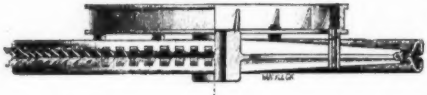
one of the downs in southern England, and, like most ventures of the kind, was a failure at the outset, as far as its practical operation was concerned. But it served the purpose for which it was built, and, after undergoing many alterations in the various details, the practicability of the thing was at last satisfactorily demonstrated, and a company was organized, known as "The Hodgson Wire Rope Tramway Company." A number of lines were built by this concern in various quarters of the globe, some of which were from ten to twelve miles in length, and one in particular was a very elaborate affair, being no less than a series of three lines, mounted upon the same standards, one above the other, and aggregating about thirty miles in length. Most of these lines were very satisfactory in their operation, others only indifferently so, and a few were absolute failures. With the panic of 1873 the Hodgson company collapsed, and the building of these lines has fallen into other hands.



HANGERS FROM WHICH BUCKETS DEPEND IN HALLIDIE TYPE OF ROPE-WAYS.

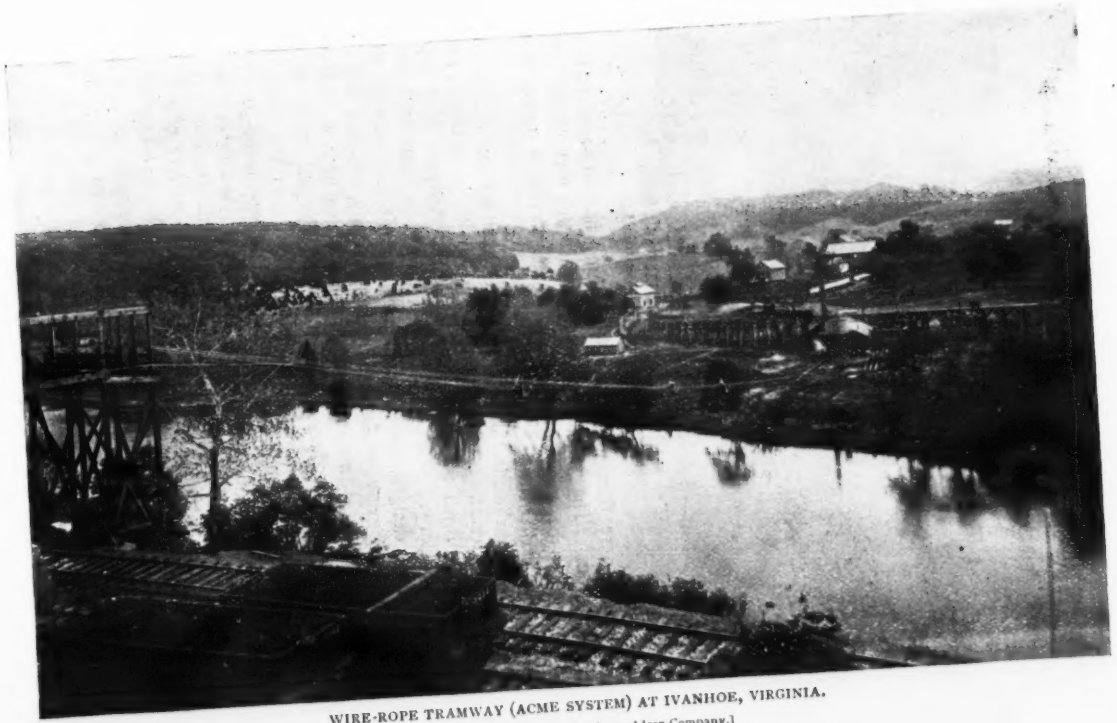


GRIP PULLEY, WITH BRAKE WHEEL.



SECTIONAL PLAN.

It is an important consideration, in any apparatus of this kind, to have everything as light as possible, consistent with the necessary strength, and one of the chief difficulties at the outset was to get suitable materials, as we have already stated. Cheap steel, and especially the higher grades of mild-tempered steel such as are now used in the construction of



WIRE-ROPE TRAMWAY (ACME SYSTEM) AT IVANHOE, VIRGINIA.

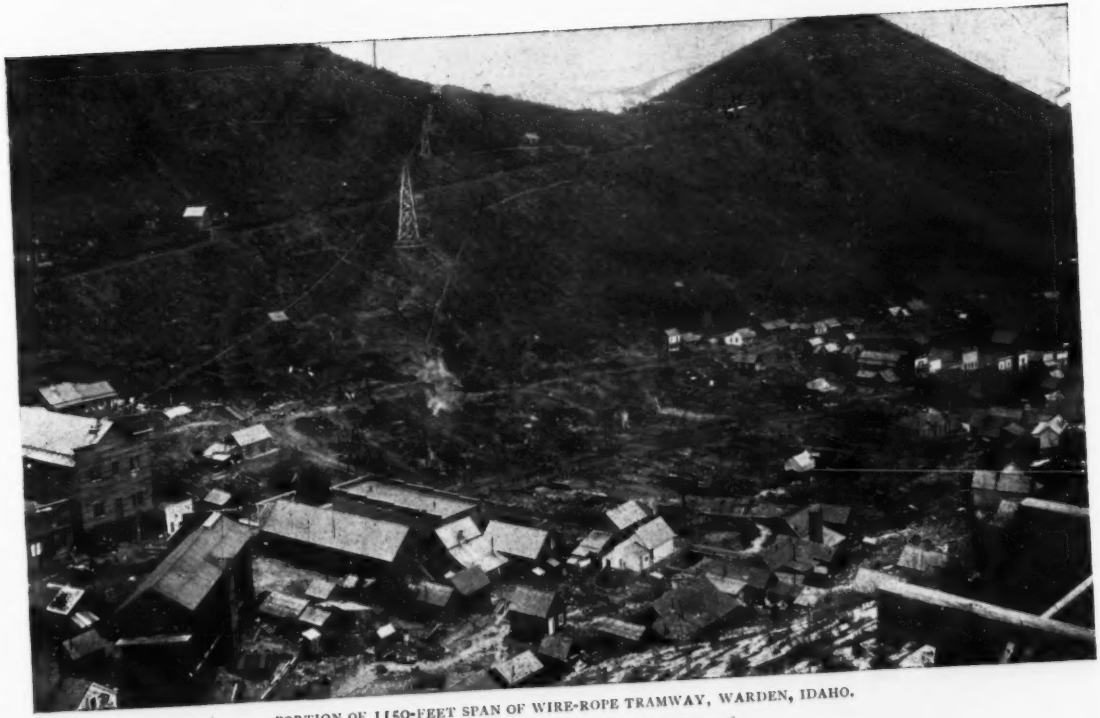
[Plant of the Pennsylvania Zinc and Iron Company.]

WIRE-ROPE TRAMWAY (BLEICHERT SYSTEM).
[Old Dominion Copper Company, Globe, Arizona.]

wire rope, were then unknown. Everything had to be of cast- or wrought-iron. The structure in consequence was very clumsy, and this proved to be a serious drawback to the successful operation of many of the earlier lines.

One of the earliest in this country was a line built for the Mount Savage Fire Brick and Mining Company, by Mr. E. G. Spilsbury, who was then the American representative of the Hodgson Wire Rope Tramway Company. Several other lines have since been built from Mr. Spilsbury's designs, among which may be mentioned one for the Juniata Sand Company, at Lewistown, Pennsylvania, which is still in successful operation. In some of the lines in this country, as well as in many of the foreign lines, considerable difficulty was encountered in the slipping of the box-heads on the rope, owing to the steep inclination at certain points, and it was found impracticable to work these lines over grades having a greater inclination than about 1 in 4.

The box-heads (or saddles) consist of light malleable-iron boxes, containing what are termed the "bearing-blocks," usually of rubber or wood. These are secured in such a way that they can be readily replaced as they wear out. Referring to an accompanying cut, it will be observed that the box-head is fitted with a couple of small grooved wheels at one side. The object of these is to free it from the rope at the terminals and other stations, and this operation is performed by providing rails at these stations, or flat bars suspended to the framework, the terminal points of which are bent down, and so placed as to

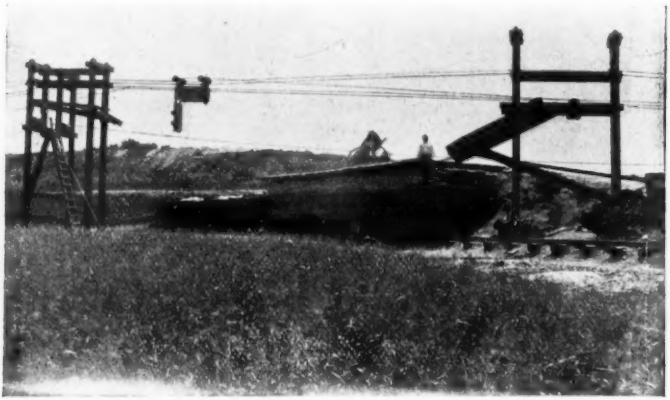


PORTION OF 1150-FEET SPAN OF WIRE-ROPE TRAMWAY, WARDEN, IDAHO.

[Plant of the Bunker Hill and Sullivan Mining Company.]

receive or engage these small wheels on the box-heads. The momentum of the buckets carries the box-heads up on to the elevated rail, and they are thence conveyed by hand to convenient points of loading or discharge, as the case may be, while the motion of the rope continues uninterrupted. The frictional contact between the "bearing blocks" and the rope is simply depended on to keep the "box-heads" in place along the line, and it is evident from this that the system is not adapted to very steep grades. Mr. Hodgson endeavored to overcome this defect by devices for gripping the rope.

It was about this time, or soon after the Hodgson system was introduced in the United States, that Mr. A. S. Hallidie, of San Francisco, became interested in this method of transportation, patented

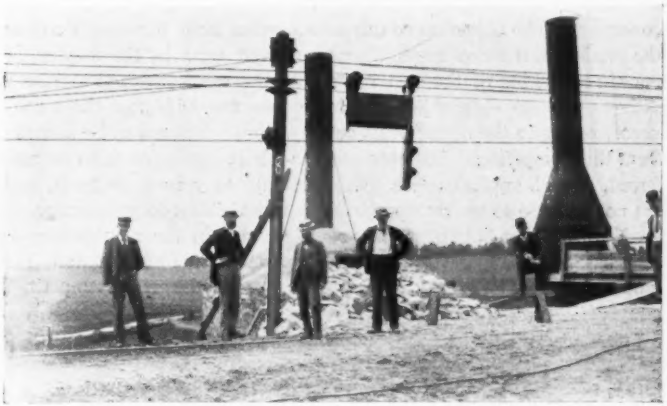


WIRE-ROPE TRAMWAY (ACME SYSTEM).

[The Cedar Hill Lime Company, Port Kennedy, Pa. Length of Line, 1450 eet; Daily Capacity, 150 tons. Cut Shows How Cars are Loaded Automatically.]

certain improvements, and introduced the system associated with his name. The distinctive feature of the Hallidie tramway is the manner in which the pendants or bucket-hangers are inseparably attached to the rope. For this purpose steel clips are used, of peculiar construction (illustrated in an accompanying cut), which ride freely over the supporting sheaves and around the terminal wheels. This occasions the necessity of loading and unloading the buckets at definite points while they are in motion, in consequence of which these lines can only be run at a very moderate speed,—in other words, about 180 feet per minute,—which requires a somewhat larger outfit of buckets than lines which admit of higher speeds.

A great advantage of these lines is that they can be operated over any grades, and for a certain fall in favor of the loads become self-acting; that is, the loaded buckets in descending develop sufficient power to haul back the empties, requiring the application of a brake at the operating terminal. The necessary inclination for this varies with the amount of material carried and other conditions, but usually is about 1 in 7. Where there is considerable excess of power developed, above the amount actually required to operate the line, this may be utilized in various ways. In all cases where the difference in elevation between terminals is very great, especially if the line is a long one, and either requires or develops much power, it is necessary to employ a grip-wheel at the operating terminal. It will be observed,



WIRE-ROPE TRAMWAY (ACME SYSTEM).

[The Cedar Hill Lime Company, Port Kennedy, Pa. Cut Shows How Stone is Deposited at Kilns.]

from the cuts we present illustrating the construction of such a wheel, that the periphery or rim is fitted with a continuous series of steel jaws, which operate in pairs on the toggle principle, and, under pressure, with sufficient force to prevent the rope from slipping. The moment they are relieved of this pressure the jaws open and allow the rope to pass off freely.

To obviate the objectionable feature of having to load the buckets while in motion, automatic loaders have been introduced, the most ingenious and best of which is the patent device of Charles M. Huson, of Denver, consisting of a hopper which travels with the bucket in the act of loading, and returns to its original position at the bin after each bucket is loaded.

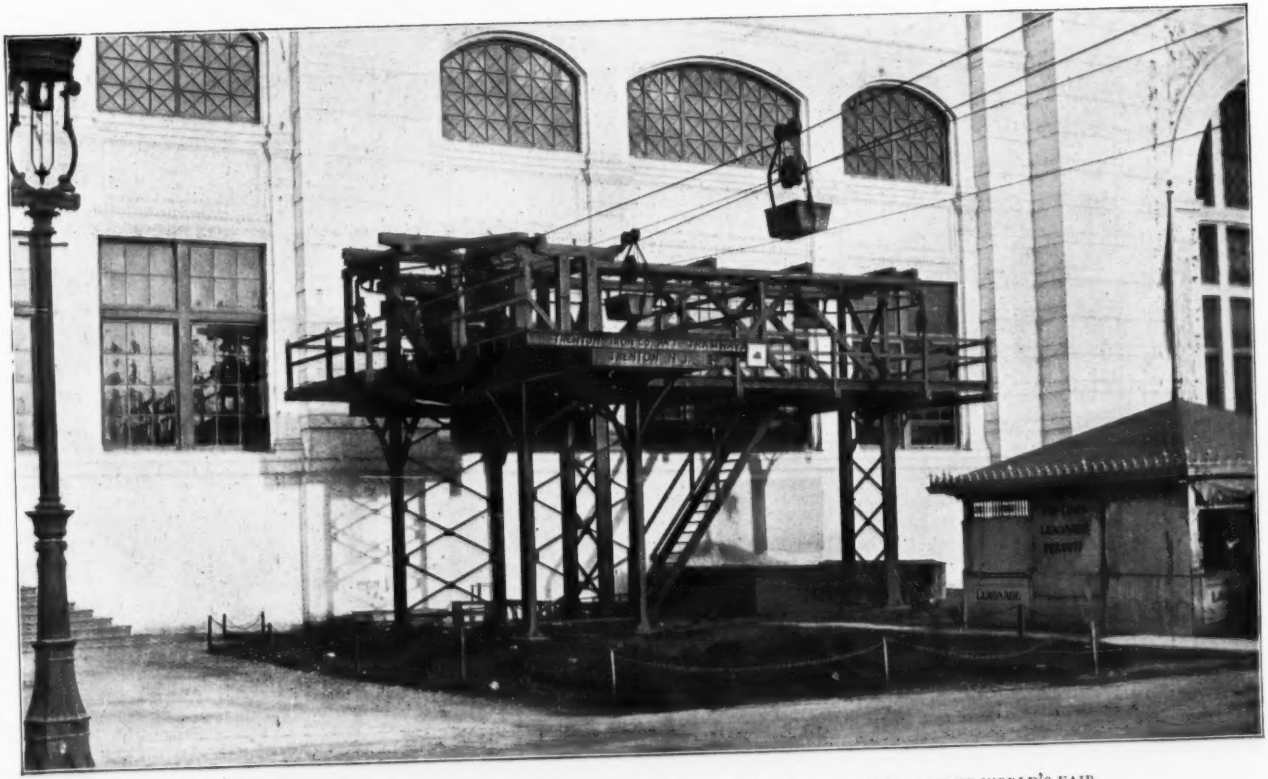
All of these single-rope tramways, whether of the Hallidie or the Hodgson types, are, from the nature of their construction, limited to the carrying of comparatively light loads, and their application therefore has been confined to the transportation of materials where the output is correspondingly light, although in a few instances, where the conditions have been favorable, heavy loads have been carried.

A system has been introduced, known as the Pickett system, in which conveyance is effected by means of two endless ropes running parallel to each other around large vertical sheaves at the terminals. The buckets are inseparably attached to these ropes, the loaded ones riding the top lines, dumping their contents in passing around the sheaves at the discharge terminal into a hopper or bin, and returning inverted on the under portion of the ropes, like the buckets of a chain conveyor. The objection to this system arises from the irregularity of the motion of the two ropes, due to uneven wear in the sheaves, or uneven stretching of the two ropes, causing the buckets to assume a skewed position,—an objection which does not hold to a chain conveyor, owing to the nature of its construction. It is not to be inferred from this comparison, however, that a chain conveyor is to be preferred, as such appliances are applicable only to very short hauls, and are not adapted to the transportation of materials for long distances.

With the vast improvements of late years in the manufacture of steel has been inaugurated a new era, surpassing in its realizations the fondest hopes of its creators. Improvements in the art of tempering,

SINGLE-ROPE TRAMWAY AT A PHOSPHATE-MINE.

[Empire State Phosphate Company, Rock Mines, Florida. Showing Portion of Cableway Used for Hoisting and Conveying the Rock from Quarry to Bins.]



THE BLEICHERT IMPROVED WIRE-ROPE TRAMWAY—EXHIBITED BY THE TRENTON IRON CO. AT THE WORLD'S FAIR.

especially, have led to the introduction of a peculiar grade of cast-steel wire, possessing a high tensile strength combined with a certain degree of ductility, and, where it was formerly necessary to employ a rope weighing two pounds to the foot, we now use one weighing less than a pound. The possibility of obtaining light steel castings at a comparatively low price has also contributed much to simplify the problems connected with aërial transportation. Under these favorable conditions Mr. Adolph Bleichert, of Leipzig-Gohlis, Germany, has brought to bear upon the subject the skill of a thorough engineer combined with a wonderful amount of ingenuity, and has developed and patented a system of wire-rope tramways that has met with great favor, and was introduced in this country about five years ago by the Trenton Iron Company, under the direction of Mr. E. G. Spilsbury.

In its general design it is similar to that first described by Mr. Hodgson as the "fixed rope" system; that is, the buckets are suspended from trolleys or carriages traversing stationary cables, and are propelled by means of a light endless traction rope, to which they are attached by grips of peculiar, very simple, and exceedingly ingenious construction. Loads up to half a ton and over may be carried in this way, and it is possible to transport by a Bleichert tramway as much as

INTERIOR VIEW OF DISCHARGE-TERMINAL.

[Wire-Rope Tramway (Bleichert System) of La Gran Fundacion National Mexicana, Santa Catarina, Mexico.]

WIRE-ROPE TRAMWAY OF LA GRAN FUNDACION NATIONAL MEXICANA, LEON STATION, MEXICO.

DISCHARGE-TERMINAL OF WIRE-ROPE TRAMWAY.

[Plant of East Shore Terminal Company, Charleston, S. C. View of Charleston Harbor in the Background.]

80 and even 100 tons per hour. The advantages of these lines have been so well appreciated abroad that railroad companies have adopted them as regular feeders to their main roads.

The details of the system have all been very carefully worked out with a view to reducing the wear of the moving parts as much as possible. The carrying cables are of special construction; and, in the "smooth-coil" cable introduced by Bleichert, the wires are laid up in such a way as to present a smoother surface than in ropes of the ordinary lay, and are larger, which adds not only to the life of the cable itself but also to that of the rolling-stock. But the best cable unquestionably is that introduced recently, known as the "patent interlocked carrying cable," from the fact that the outer wires are drawn or rolled to shape and laid up in such a way that they interlock one with the other, presenting a perfectly smooth surface, and possessing sufficient flexibility to be shipped in coils. This type of cable gives the highest degree of service, with a minimum amount of wear in wheels.

These cables are usually anchored at one end of the line, and weighted at the other to the proper tension, by means of boxes filled with stone or other suitable material, and the strain upon them, if the cables are kept properly greased, is governed almost entirely by the amount of weight so applied, being independent of the loads carried, provided these are not so great as to cause the cables to sag beyond the range of movement of the counterweights. This is not likely to happen, even where there is ample room for the deflection of the cables

corresponding to any load, if the weight-boxes are properly hung, as any great difference in deflection produces a comparatively small movement of the weight boxes, and the strain on the carrying cables therefore is practically uniform.

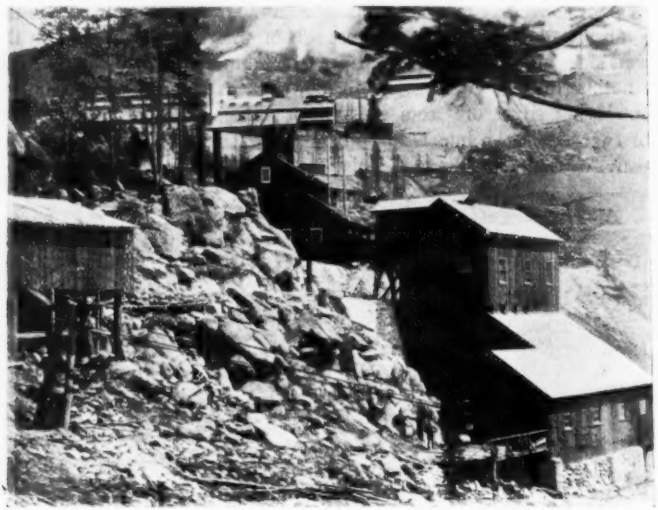
During 1893 several lines were built that were remarkable for their long spans. The line of the Susquehanna Water Power and Paper Company crosses the Susquehanna river, at Conowingo, Maryland, about ten miles above Havre de Grace, and consists mainly of two long spans each 1700 feet in the clear, the central support, which is 100 feet high, being located upon an island in the river. The line is used for conveying coal and supplies from the Port Deposit branch of the Pennsylvania railroad, on the east side of the river, to the mill on the west side, and also for taking paper over from the mill to the railroad. Another line, at Guanacevi, Mexico, about 1¼ miles in length, for conveying silver ore from the Wilson mines, has in it one clear span of 1350 feet. An interesting line is that of the Penn Glass Sand Company, of Emlenton, Pennsylvania. It is used to convey sand for glass-

WIRE-ROPE TRAMWAY (BLEICHERT SYSTEM).

[The East Shore Terminal Company, Charleston, S. C. Length of Line, 700 Feet; Daily Capacity, 500 Tons.]

making purposes from mines in Venango county, Pennsylvania, to the works of the company, a distance of about a mile. The mines are on the west side of the Allegheny river, and the mill is on the east side, alongside the main track of the Allegheny Valley railroad at Scrubgrass, near the station of Kennerdell. The span across the river is 1100 feet, and the main cable upon which the loaded cars travel is of the patent locked-wire type, 1⅛ inches in diameter.

Two lines were built recently for the United Concentration Company for the conveyance of gold-ore from mines in Snohomish county, Washington, to the concentrating-works of the company at Monte



WIRE-ROPE TRAMWAY FOR CONCENTRATING-WORK.

[Plant of Bi-metallic Mining Company, Granite, Montana.]

Cristo. The lines meet in a common discharge terminal at the bins of the concentrating-works. The longer of the two lines communicates with the Pride of the Mountains mine, and the shorter one with the Mystery mines. The Pride of the Mountains mine is located on the side of a steep mountain, and the line crosses a deep gulch known as Glacier Basin, a clear span of about 1400 feet, between this mountain and Mystery Hill. From Mystery Hill the line passes over a snow-slide on a very steep inclination, and thence to the mill, the total fall being about 1700 feet. The carrying cables from the loading terminal to the tension station on Mystery Hill are of the patent locked-wire construction, on both the loaded and empty sides.

Both lines cross the snow-slide, in spans varying from 800 to 1000 feet. What few supports there are have been located at the most favorable points and protected from the snow by sheds. The accompanying illustration of the line of the Bunker Hill and Sullivan Mining Company shows a portion of a span of 1150 feet, where the line crosses the town of Wardner, Idaho. The line is 9000 feet long and has a daily capacity of 400 tons.

In the design of these tramways the practice is to lay out the line of the carrying cables very carefully for a given tension and erect the supports to this line. The cables, however, are actually weighted to a lower tension, so that these may not rise out of the saddles upon which they rest, which might happen if the applied weight corresponded with the curves regulating the height of the supports. Where the line is a very long one it becomes necessary to weight the carrying cables at intermediate points, in order to allow for friction, and preserve as nearly as possible a uniform tension throughout the line. Tension stations are introduced at such points, the construction of which is such as not to interfere in any way with the movement of the cars, and requiring no attendants. As a rule these are spaced from 4000 to 5000 feet apart.

The saddles upon which the carrying cables rest are made with curvatures of large radii, so that the carriages ride over them very easily, and there is no difficulty of maintaining speeds of three to four miles per hour. Taking this into consideration, with the fact that much heavier loads are carried than on the "single-rope" lines, the number of buckets required for a given capacity is only about one-third as great, making less to load and unload and reducing the wear and tear correspondingly.

One great advantage of these lines lies in the fact that any grades, no matter how steep, can be surmounted; and, in fact, there is no profile so rugged as to present insuperable difficulties in this respect. A precipitous rise or fall, for instance, presents no obstacle, since the cable lines can always be laid out so as to bring the inclination within the proper limit, which is about 45 degrees. Valleys and streams are crossed by long spans, as already explained. These points are well illustrated in the profile of the Granite Mountain Mining Company's line at Rumsey, Montana.

The construction of the grips for securing the cars to the traction rope is such that when the cars arrive at either terminal, or any station along the line, they are detached automatically and run off on suspended rails to any desired point of loading or discharge.

Various styles of grips have been used, some depending simply on frictional contact with the traction rope to hold them in place, and

WIRE-ROPE GRAVITY INCLINE, AALSUND, NORWAY.

others of a positive character, designed to straddle lugs secured to the traction rope at intervals regulated by the amount of material to be transported. The latter are preferred where steep grades occur. These lugs are made in halves, and are applied in such a way that they can be readily replaced by new ones or moved to other points on the rope from time to time, as circumstances may require.

The usual arrangement is to load from bins, but, if desired, the buckets may be transferred to special trucks, which traverse surface tracks. These trucks are designed to accommodate one, or, more commonly, two, buckets, and are run into the mine, quarry, or other loading point, filled at the face of working, returned to the tramway terminus, and sent over the line without any rehandling of the material. In some cases the buckets themselves have been fitted with wheels.

Special scales are employed for weighing the cars, and counters for registering the number of buckets transported. If desired, the cars may also be raised or lowered by elevators at either terminal; in fact, the system is very complete in all its appointments and can be adapted to meet almost any requirements where the loads are within what men can handle advantageously.

The cost of installation of a Bleichert line varies, according to the capacity and terminal requirements, from $8000 to $16,000 per mile. The cost of operation depends upon the output, price of labor, whether

the line is automatic in its action or requires power, and other conditions, and ranges usually from 3 to 10 cents per ton per mile. Under ordinary conditions but five men are required: an engineer or brakeman, as the case may be, to operate the line, and two men at each terminal, one to attend to the loading or unloading of the buckets and the other to do the gripping. It is only in cases where the output is very heavy, where intermediate stations occur, or where there is much switching and handling of the buckets at the terminals, that more men are required. The cost of maintenance is also comparatively low, and as a rule will not exceed in a year 8 per cent. of the investment.

The line of the Split Rock Cable Road Company near Syracuse, New York, for instance, which is used for transporting lime-rock, is 16,500 feet long, and has a daily capacity of 750 tons. It passes over rolling ground, where the grades are moderate and long spans do not occur, the discharge terminal being but about 240 feet lower than the loading terminal. At the discharge terminal the rails extend over a long line of kilns, into any one of which, by means of a series of switches, the lime-rock is discharged. As a precaution against fire the entire superstructure over the kilns is of iron. The line has been in operation about four years, running night and day. During 1891, nearly 196,000 tons of rock were carried over it, at a cost of about 6 cents per ton per mile, covering all expenses, including, in addition to the labor and materials for operation and repairs, the expenses of right of way and taxes.

A very interesting exhibit of the Bleichert system was made by the Trenton Iron Company at the World's Columbian Exposition, a complete working line having been erected there, showing all the details of construction, and the various styles of cars used. This line ran from an elevated station adjoining the Mines building, over the intramural railway, to a point near the exhibit of the Pennsylvania Railroad Company. The line was kept in constant operation, being used at times to carry materials to the Mines building, while throngs of people were passing beneath it all the time, and was one of the features of special attraction.

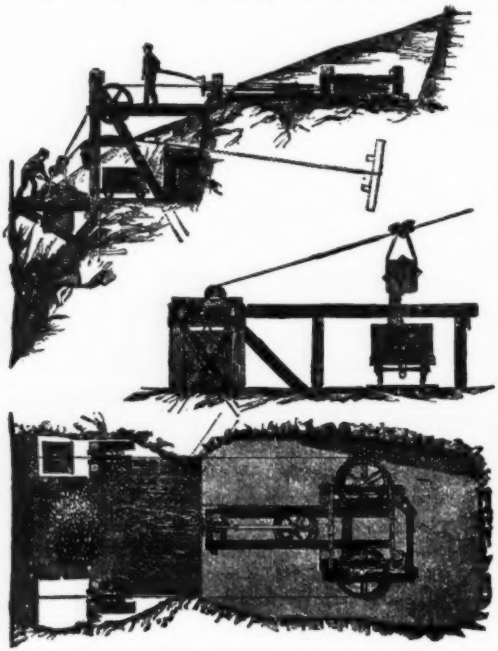
The several views which are presented here of Bleichert lines will give a fair idea of the wide application of the system; in fact, the number of these lines that have been installed now mounts up into the hundreds.

The different kinds of wire-rope tramways thus far described require the use of bins or other means of transferring the material to and from the tramway buckets, excepting in the case of the Bleichert system, where the buckets are transferred to special trucks, and even in this case the labor amounts to practically the same thing, and the only

advantage derived is in the saving of material effected by not having to rehandle it.

Several systems have been devised for the conveyance of cars adapted to traverse overhead as well as surface tracks. In the first lines of this character the cars were carried upon two endless ropes, running parallel to each other, the same ropes serving to both support and move the loads, and were little more than a complication of the old Hodgson type of tramway.

In the system recently patented by A. H. DeCamp, and introduced as the "Acme" system, these functions are performed independently, as in the Bleichert system, the cars traversing a double line of flat steel bands, and motion being imparted to them by means of light endless traction rope, which travels centrally in respect to the track bands, and to which the cars are attached by patent grips. The track bands are laid "flatwise" in the supporting saddles, and are joined by clips of simple construction, over which the cars ride very easily. If the loads are very heavy these bands are doubled or trebled, one being placed above the other. Ropes may be used in place of the flat bands if preferred. The principles which govern the height and spacing of the supports are the same as in the Bleichert system. The terminal structures are simpler, since no overhead rails have to be provided for. The cars, after being detached from the traction rope,



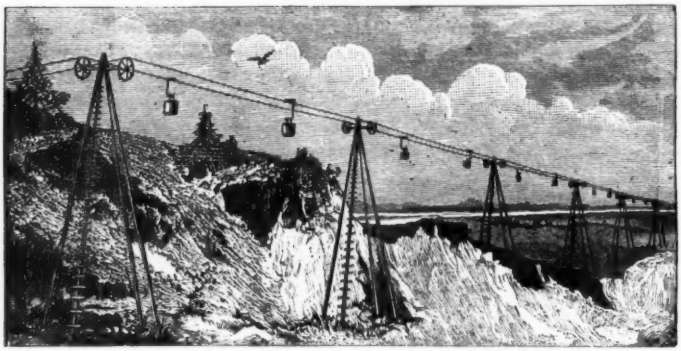
TERMINALS, WIRE-ROPE GRAVITY INCLINE.

which operation is automatically performed, are simply conducted to the ground on to surface tracks. For quarry-work this is very convenient; light portable tracks being used, which can be shifted as the face of the quarry is worked off. The cars are usually designed to dump from the bottom, which permits of an automatic discharge at any desired points along the line of the tramway, a feature well illustrated in the views of the Cedar Hill Lime Company's line at Port Kennedy, Pennsylvania, one showing how railroad-cars midway between the terminals are loaded, without arresting the motion of the car, and the other how the stone is similarly deposited at any of the kilns where needed. We also present a view of a line at Ivanhoe, Virginia, used by the Pennsylvania Zinc and Iron Company for transporting iron-ore from a branch of the Norfolk and Western railroad to their works on the opposite side of New river. In this line ropes of the patent interlocked pattern are used in place of the flat bands.

Where the ground for the greater part of the distance admits of surface tracks, but is rugged in places, with ravines and rivers to be crossed, a combination of surface tracks and "Acme" tramway may be employed to advantage, the latter being applied only to the bridging of the valleys, streams, and other points where it would be impracticable to lay surface tracks. By transporting the material thus in a continuous string of comparatively light loads (each car being provided with an independent grip), it is evident that a very large tonnage can be sent daily over a surface road of light rails, while the suspended way renders bridges and trestlework unnecessary, and the first cost of the roadway is therefore considerably reduced. The cost of operation, maintenance, and repairs in this system will compare favorably with that of any other mode of transportation.

Where there is considerable difference in the elevations of the terminal points, aërial inclines are constructed which operate in the same manner as an ordinary engine or gravity plane, the carrying cables simply performing the function of surface tracks. The traction rope in this case, instead of being endless, terminates with each of the two cars. If the load is an ascending one, the line is run by a motor of some kind, but if it descends, gravity becomes the motive power. A line of this character at Aalsund, Norway, has a clear span of 2250 feet. The angle of inclination is about 45° and loads of 1200 pounds are lowered at each trip, the descent occupying about 1½ minutes. One hundred tons of ore per day are transported in this way at a very low cost. Similar lines are used in Switzerland for lowering logs down the mountain-sides. In many lines of this character the moving rope is endless, and passes around a sheave at the lower terminal, which may be counterweighted or stationary according to circum-

stances, this construction being necessary in cases where the sag of the rope otherwise would cause it to drag on the ground or interfere with objects under the line. This arrangement also permits of operating from the lower terminal if desired, as exemplified in a line for conveying stores from the town of Gibraltar to the fortifications at the summit of the rock. This line is 2200 feet long, with a vertical rise of 1200 feet, and the two cars are designed each to carry a load of 1000 pounds. The motive power is supplied by an engine at the lower terminal, and the cars are run at a speed of 450 feet per minute. There are six intermediate supports, the last span stretching from the rock bluff to the town, being 1150 feet in the clear. A similar line is now being installed by La Gran Fundacion National Mexicana, near Santa Catania, Nuevo Leon, Mexico, for lowering ore down a steep hill, the buckets of which are self-dumping. The length of the line is 800 feet and the fall about 440 feet.



ARCHITECTURAL EDUCATION FOR AMERICA.

I.—THE ECOLE DES BEAUX-ARTS.

By Arthur Rotch.

IT would not seem extraordinary if a man about to build a house should say that he intended to consult an engineer as to the drainage of his site, and to employ a designer to plan for his requirements and to give him within and without an artistic building; that he should have the detailed specifications of materials, hardware, etc., written by an experienced builder and the materials themselves submitted to a practical chemist to test their durability; that construction-drawings should be made and carried out by a skillful engineer responsible for all settlements, shrinkage, or leakage; that the plumbing and heating should be devised and supervised by experts; that an artist should be engaged to watch and correct the models for carving and moldings and the execution of them; that the same or another genius must choose the shades of paint or stains to harmonize with whatever he, the owner, might select for papers or hangings; that he should expect to have always on the spot a competent overseer, and, though in view of the multifarious crafts and arts involved no one man might be competent in them all, he must have always on hand an expert, at whatever cost, in each department to pass on work and materials; also, that he must have an expert accountant to keep these many accounts balanced, so that at any time the owner could know what payments were falling due to contractors on certificates from the heads of departments. This accountant should also watch carefully the certificates for payments to detect errors by work omitted, or for allowances in the contract to be deducted, and should be competent to discuss these questions with contractors as a business manager might. If a man should say all this to his friends, they might retort that it would involve a very expensive staff, and ask, even if expense was not to be considered, who would be chief of staff and keep these departments and their heads coördinated? It is possible that it would then occur to the owner to supply an architect as chief of staff. Probably that would be satisfactory to all concerned.

Now, no doubt a man who should act as in this hypothetical case would have a better built, more comfortable, and more beautiful house than his neighbor, and yet, in spite of the immense sums lavished on buildings, this sort of expense is practically never incurred.

The qualification of all these experts is needed to carry a building to completion, and an architect is expected to fill all the gaps. Why should he do all these things? Because, from the nature of the temperament which called him to such a career, his pride will urge him to make his building the best he can make. The remuneration of an architect is so small, compared to his expenses, that he is forced to look to results satisfactory to his conscience and to gratified ambition as the chief results of his career. He will make a gallant fight to fill the places of all the needed experts above mentioned, and his enthusiasm will receive a rebuff as soon as he falls short of his impossible attempt. He will be blamed because he is not omnipresent or omniscient, but as he knows he has only himself to thank for undertaking the impossible he will not complain openly.

It has come, through the architect's own fault, to be considered his duty to place at his client's service all these many qualifications, each of which presupposes special training and the exercise of which in the aggregate requires a broad-minded, forceful personality and the tact born of knowledge of many things and many men.

If, then, we ask how one can best fit an architect for his career, there seems to be but one answer: the broader the foundation laid for it the better; the most liberal education is the best. It is obviously impossible for a young architect to know the multitudinous details which experience alone can teach. Every day and every year must bring its store of such knowledge. But there is another kind of knowledge which is not picked up in practice and whose absence experience only emphasizes. There are whole ranges of subjects which can be learned only from the professor or in the academic laboratory, and these studies which stimulate investigation and train the judgment are not to be found in the most extended practice. Chemistry and its kindred sciences, which decide the use of new materials, must be studied in the laboratory and lecture-room. Heating and ventilation and many other branches can be learned expeditiously only under a professor, and where so many subjects must be studied the short road to learning is the best for the architect. It seems, therefore, that at least a certain degree of academic training is needed to round out an architect's education, even supposing that he can learn the esthetics of planning and designing in office-work.

As an architect's practice ever offers to him the solution of new problems, and as he is tempted constantly to copy blindly the fashion of the day, it is of the utmost importance that he should face his bewildering conditions with sound principles of design and construction.

The young architect requires a pure esthetic code to guide him

when bewildered by specious influences. Like all moral influences such esthetic principles must be absorbed slowly and in a propitious atmosphere. Traditions for a time must submerge personality. Traditions which are the fetters and limitations of an old civilization are stimulating guides in the new.

Feeling the need of such traditions, Americans have been most attracted by the École des Beaux-Arts at Paris. It is magnificently endowed, with every facility for and every incentive to study all branches of art. Its splendid library is freely open to students. Lectures in history, esthetics, mathematics, and the constructive sciences are given by eminent specialists. Frequent *concours* offer distinction in many branches. Founded in the middle of the seventeenth century, its early teaching was a timid classicism whose chief merit was the close study of the old Roman plans,—the most splendid the world has seen. Still keeping the latter in view during this century, and especially in the latter half of it, the School designs have gained greatly in vigor and richness. An influence of value came from Viollet-le-Duc's attempt, a generation ago, to substitute for Classic models Gothic designs in the school ateliers. The revolution did not succeed, but the great medieval archæologist's protests against the sham construction of the Roman Classic style and his exposition of the beauty of truth in constructive design have emphasized the value of rational architecture.

However artists may differ as to styles, the principles of largely-conceived symmetrical plans are immutable, and the École des Beaux-Arts student in this has no rival elsewhere. In general it may be said of the school that its influence always makes for a large symmetrical treatment of masses and a subordination of details in the composition.

The training of the École des Beaux-Arts is such that the students in architecture, as well as those in painting and sculpture, graduate with definite principles to guide their subsequent work. The students under this liberal instruction on returning to America rarely reproduce French types of architecture, but, applying the principles of design they have imbibed, seek to express the functions of the building by a logical use of the materials available.

This is the mental attitude our architects should have. They are confronted with novel problems and new exigencies. These can only be met successfully by cultivated training which leaves no *parti pris* in style. The well-stored mind must be alert to seize new points of view; then, guided by sound principles, it will produce rational architecture, *i. e.*, buildings whose purposes impose their plans while the available materials decide their exterior treatment.

There is another advantage which belongs peculiarly to this institu-

tion, and that is the all-pervading artistic influence in which its students are steeped. The close connection of the students in architecture, painting, and sculpture, their great numbers, their distinguished professors in active career, the ardent competition and penetrating sense of the value of hard work, all create an incomparable atmosphere for artistic culture.

It is distinctly to the Beaux-Arts at Paris and its direct influence through pupils, or indirectly through the schools in America which have followed its lead, that the splendid buildings in its own chosen style at the World's Fair were erected.

In conclusion it may occur to the reader, as it has to the writer, that there is a curiously familiar sound to the above considerations—a haunting sense of having heard the drift of it before. And so we have. It is now nearly a generation since the discussion as to college education waxed high. The American people have long since settled that. We rarely hear now the old-time tirades against the waste of time for business-men to go to college. Americans want to be something more than subordinates, and they know that the most liberal education leads to the front.

II.—A PRACTICAL TRAINING.

By Robert D. Andrews.

THE young American who intends practising architecture has two recognized resources for his education: the architectural school and the practising architect's office. These, between them, with a little foreign travel, are supposed to supply all that is necessary student to know before he begins practice for himself.

Our schools are modeled upon the schools of Europe, where for the most part design is taught in its theoretical sense. Their general air is one of conservatism. Past achievement is not scrutinized in the light of modern thought and tested by modern standards, but certain types of development are conventionally accepted as representing the best the past has to offer us, and the *summum bonum* of modern design is to secure the closest possible approximation to these conventional types. The objection to the ordinary school is not so much on the ground of what it teaches as of what it leaves untaught. Design on paper can at best be only theoretical. The demonstration of its practical fitness or unfitness is unattainable. Hence it is not surprising to find the schools which have no equipment for the practical demonstration of the relative fitness or unfitness of design centering their attention upon such virtues as may be displayed on paper. Our criticism of them must be the broad one that they lack such equipment.

That theoretical design which the schools teach, our unfortunate conditions of practice tend to enforce. The established system of paying all architects alike, on a commission basis, makes it necessary for an architect, if he would prosper financially, to secure a large amount of work. The money premium is set on quantity, not quality. As a result the architect becomes primarily an organizer, a hirer of draughtsmen, a man of affairs. The work of his office becomes specialized. The designer designs, the constructor constructs, the superintendent superintends, and the architect busies himself with administration and his clients. The superintendent is the only person who is brought into close and constant contact with the actual work, and he is the one person who is considered least worthy to design.

We find that in the office, as well as in the school, the student, or draughtsman, whose education we are following, has no systematic means for coming in touch with the actual materials for which he is obliged to design. He is rarely permitted to follow the execution of the work he has drawn, and frequently never sees it. As he receives his most important inspirations by paper, through the medium of books and photographs, so he is obliged to express himself by paper. Thus in office and in school, alike, the student is shut out from the influence of the realities of the art he is supposed to be acquiring.

Now, as a matter of fact, it is acquaintance with just these realities of building that the modern student misses, which has created the very art of design he is aiming at. In the centuries immediately preceding the crowning achievements of both Greek and Gothic architecture, the architect, as we know him,—a person forcing designs upon all sorts of craftsmen,—was undreamed of. Every craftsman made his own designs because, forsooth, there was no one to do it for him. Art, as such, was ignored, and the carpenter and mason and smith worked in all simplicity of mind at their respective tasks. Therein lay the charm of their work, and the secret of their ultimate growth and power. For in their close and undisturbed relation the material spoke with its worker, and told its secrets to him. It taught him its utmost resources, and its limitations; it lent its grace to crown his work, its strength to fortify his reputation as a craftsman, so that his heart went out into it, and he loved it in all unconsciousness and sought to display it ever more and more advantageously. Thus grew these two great races of Europe to the flower of artistic achievement, simply by working out, without any preconceptions, the familiar demands of their own local conditions. No foreign traditions dominated them, no school restrained them, and humble artisans were the means employed to dower the world with yet unrivalled beauty.

The architectures of Greece and of thirteenth-century France are the

fountain-heads of our noblest inspiration because they spring from the soil. They express the heart of humanity. But after they had revealed their unexpected splendor and won the popular attention, men began to consciously seek to secure for their own times the beauty that was in the earlier work. Art woke to self-consciousness, and first learned to seek her own ends. Her high priests, the patron and the architect, arose and taught the craftsman how he should design. And in proportion as the architect gathered the rights of design one by one into his hands, and left the craftsman's task an unimaginative and purely mechanical one, the better men deserted the crafts, until only the broken-spirited and dull remained. More and more the architect was compelled to rely upon those qualities of art that may be consciously effected, formal symmetry, grandiose scale, complex and ingenious disposition of detail and mass. The old, fine, human sentiment of the work perished, and art became a matter of the intellect, often powerful and impressive, as a cliff or the ocean is, if only by reason of size, but no longer lovely in every part.

If we recall the architecture of the United States about the year 1850, we can form a just estimate of the depths of degradation to which this separation of design and execution has led. The recent revival of architecture here is due to the stimulating effect produced upon our architects by the contact with the vital work of Europe made possible by photography and ready modes of travel. The beneficial effect of this stimulus is already waning, as we may see by the increasing introduction of the meretricious features of Roman design.

We have the question squarely to meet, whether we shall drift along and repeat the experience of ancient Rome, borrowing our architecture from our betters, and using it as a cloak for luxury and mental idleness; or whether we shall make a stand for an honest, self-respecting, and progressive art. It seems to me a very critical time, and upon the action of the present generation the hope of American architecture may depend.

I have tried to express, as forcibly as the brief limits of this paper permit, the weak side of our architectural education, and the especial nature of its weakness. My suggestions for arriving at a better state of things are these:

First, to bring the architect (and the student with him) closer to his work, I would like to see the client demanding a certain specified amount of his time at the building, and paying him a specially agreed upon sum for his services instead of the usual commission. I believe the architect could save to the owner under such conditions a sum nearly equal to his present fee. The architect's office for that work should be immediately adjoining the building, as a contractor's is.

The advantage to the draughtsman in being always at the work is apparent.

Second, to improve the school training, I would join to each school a school of building trades. I can imagine these two schools on either side of an important central court, with museum, library, hall, dining-room, and gymnasium in common. One head would insure harmony of coöperation. The main object in view would be to familiarize each class of students with the other's point of view ; and the familiar intercourse between the two schools, with the mutual understanding and comprehension resulting, would constitute an important factor in the results expected.

I would revise the present disconnected modes of study, especially in elementary courses, so that the occupation of one hour would form a proper sequence to that succeeding, bringing the teacher's convenience to suit the pupil's, rather than otherwise. I would establish the lines of study more or less on structural rather than historical development, considering organic relations of highest importance. Beginning with the nature and capacities of common materials, constantly illustrated by reference to their historical employment, I would lead the student on to the construction of the familiar parts of building in their natural order, arriving at the most abstract and subtle creations of art at the end. Meanwhile, problems in the use of materials and practical design would be carried out in the courtyard. This courtyard I imagine to be a veritable museum of current art. The architect designs, the craftsman executes, while the library and museum furnish their silent comment. The craftsman, too, should match his design against the architect's, the courtyard constituting a free parliament. The architect might leave the school as a craftsman, or the craftsman as architect. The conception of the school is not to produce fine craftsmanship or fine design, but to gain good architecture ; to make both architect and craftsman feel that the other is essential to his success ; to establish that bond of intellectual sympathy without which the best of intentions are useless.

Thus may we begin that reconciliation of execution and design, of architect and craftsman, whose present wide separation is a reproach to our intelligence, and the worst menace to our art.

EARLY ARCHITECTURE AND ENGINEERING IN PERU.

By Mme. Alice D. Le Plongeon.

EVER since the Europeans have known America the attention of the fortune-hunter and the antiquary has been attracted particularly to Peru. It was the treasure-house of the Spaniards in the days of their undisputed control, while for the scholar it has been, and is, a rich field of research. From the coasts to the dizzy heights of the Andes vestiges remain of the handiwork of a prehistoric race, while the soil is white with the bleached and powdered bones of millions of human creatures. For Peru, up to the time of the Spanish conquest, was densely populated, although the people rapidly diminished in numbers under the harsh treatment of the invaders. Many thousands perished in the mines, and these were only one portion of the hapless victims of the Christians. The Inca civilization, which many suppose to have been the principal and dominant power in ancient Peru, was but one incident in the history of that country.

The first Inca, Manco Capac, made himself a king about A. D. 1020 or 1021. Atahualpa, the last Inca who actually ruled over his people, was put to death by order of Pizarro in May, 1532. Thus the whole Inca reign endured for only a little more than five hundred years, and was, comparatively speaking, an event of modern times. Certain native records go to show that Manco Capac was descended from a line of Peruvian kings. But all the country now called Peru was not in former times occupied by one nation. On the coast were the Yungas and the Chinchas (also called Changos), who were conquered by the Incas after a stubborn resistance. Older people than those of the Inca period were the Aymaras, who in turn were preceded by the Collahuas. Up in the region of Lake Titicaca vestiges are found of the handiwork of yet another people, older and more civilized. The ancient city of Tiahuanuco, now reduced to scattered stones, bears witness to this.

As a result of its varied population the investigator finds in Peru more than one style of early architecture. The variety of materials employed afforded a reason for this, more powerful than mere fancy. It was a matter of convenience, the builders utilizing those materials nearest at hand and best suited to the climatic condition of the various

localities. Thus, the cities on the coast, where no rain falls, were built of sun-dried bricks—adobes—not only by the early people of those parts, but by the Incas themselves after they acquired supremacy. The material most suitable for that climate was already on the spot. Further inland, in the valleys, where stone abounds, it was used exclusively, roughly piled up as shown in an accompanying illustration, made from a photograph of a gateway at Calaveras. Up in the mountains the Inca buildings were made altogether of stone, as were those also at Tiahuanuco, where we may see the most marvelous stone-cutting to be found in any part of the world. This work, the natives say, was done so long ago that it was before the sun shone in heaven,—their poetic way of saying that the history of the place is lost in the night of time. Pinelo, the well-known Spanish writer, compared the walls of Tiahuanuco with those of Assyria. Montesinos claimed hundreds of centuries for some of the Peruvian structures, but his work is not credited.* In his work, "Sacred Mysteries," Dr. Augustus Le Plongeon has explained that Tiahuanuco was probably the work of Mayas, and may therefore be coeval with the early civilization of Egypt and Assyria.

There is no way of ascertaining exactly the age of the cities on the coast. If called upon to give an opinion, we should say that they are between fifteen hundred and two thousand years old. But they must have been built on the ruins of still older cities, if we may judge from the vast number of burial-places and from the images of wood and stone found forty to sixty feet below guano-deposits, which deposits have been estimated to increase only between one and three inches in a century. It has been suggested that these remains belong to the period of "the mound-builders," but we have no means of verifying this.

The whole country is covered with vestiges of towns and villages. Beginning with the architecture of those on the coast, it is evident that size and solidity were the chief aim of the builders. The city of Chimu Canchu, not far from Trujillo, seems to have been three or four miles square. There are vestiges of a great causeway, forts, palaces, and burial-places that have been rifled of their precious contents.

Generally speaking, the houses were quadrangular, but some were round or polygonal, to suit the space in which they were erected. The walls were remarkably thick,—as much as ten, fifteen, or even twenty feet at the base, in the larger edifices. In smaller ones, poor dwelling-places, they were four or five feet thick, and sometimes only one foot. The walls were sloped on both sides, decreasing in thickness all the way to the top, so that a wall twenty feet thick at the base would terminate in a thickness of only three or four feet. This insured extreme

*Prescott, Vol. II.

solidity, and the method was perhaps resorted to in consequence of the violent earthquakes so frequent in that part of the world. The majority of the buildings were fifteen to twenty feet high, generally with no second floor. In Chimu Canchu, Sacsahuaman, and some other cities there were houses of two and three stories, their total height being fifty or sixty feet.

The adobes used in building were of two kinds. In the course of time these bricks have become so hard that it is difficult to break them, even with steel instruments. This is also the case with the elaborate ornamental stucco-work, of which an illustration is given, showing the interior of a large room in a three-story building. One kind of adobe used was cast in molds. An interesting fact is that measurement has proved such bricks, in many different localities, to have been of the same size,—namely, eighteen inches long, nine inches wide, and five inches thick. Clay mixed with gravel and chopped grass were the materials used in making them. After having been sufficiently dried in the sun, they were laid, in the building of walls, just as the modern bricklayer does his work. Clay was used to make them adhere. To-day, in Peru, adobe walls are built in the same way, mortar being used only with burned bricks.

Other adobes, found very largely in the old city of Pachacamac, and evidently of greater age than those above described, were not cast in molds. They are irregular, unshapely, rounded, apparently like a mass of moistened clay, rolled and pressed between the hands, and left to dry without further finish. Finger-marks are visible on the surfaces. These adobes are found principally in sepulchral mounds and houses of the poorer people. The adobes most commonly employed on the western slope of the cordilleras in all kinds of edifices are called *paredones*. Their shape is cubic and rectangular, being six to eight feet long and three or four feet thick.

Walls entirely of mud were built then, as they are yet in that country. A form was made with boards held together by ties so arranged as to be easily removed. The form was similar to that used in building concrete walls. In it the workmen placed a quantity of moistened earth, which they treaded or pounded with a wooden or stone pestle or stamper until the mass was solid. They then added more earth and repeated the stamping process until the form was filled, when the boards were taken apart. Such walls became hard enough to resist the elements and the earthquakes.

At Chimu Canchu, among the great number of buildings of which remains exist, one is in a state of preservation that enables us to obtain a correct idea of the general method of construction. It is believed that the building may have been a prison ; it contained forty-five rooms or

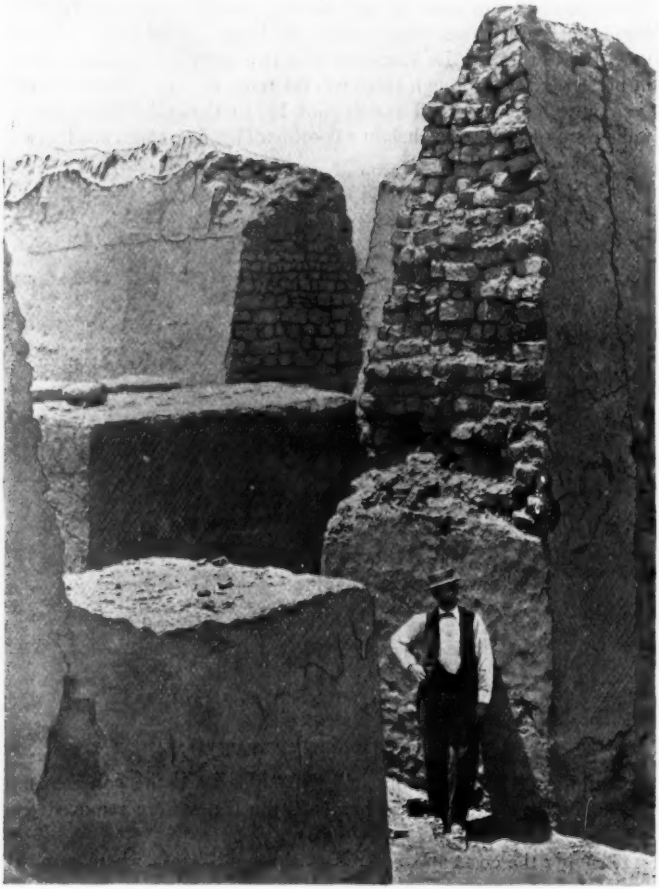
cells, each isolated, and having no entrance except through a square hole in the roof. The walls and the roof, which is four feet thick, appear to consist of a sort of hard concrete, formed of clay and pebbles. Walls and ceiling were clay-plastered and smoothly finished. The roof was so solid that Dr. Le Plongeon and two other persons rode over it in perfect safety, although there was no trace of any wooden or stone beam anywhere. Careful examination led to the belief that when the walls were of the desired height a flooring of bamboo canes was laid over

REMAINS OF A GATEWAY AT CALAVERAS.

the building. On that strong and resistant surface the concrete mass was applied, and when it had hardened the canes were removed from beneath.

Leaving the coast and ascending the cordilleras, where rain falls copiously, no more adobes are found. All the structures are of stone, —a material found on the spot and best suited to withstand the torrents of rain. In some constructions, particularly those of little pretension, the stones were cemented with clay. But in the houses and fortifications of the eastern slope the stones were hewn and adjusted with such precision that it is not always easy to determine their line of junction.

The Peruvian stone-cutters had tools of copper, tempered with tin.



ANCIENT ADOBE WALLS AT CHIMU CANCHU.

These are frequently found in graves, but when tried on hard stone they soon become blunt and useless. It would seem, therefore, that the workmen must have had other means to enable them to accomplish their remarkable stone-cutting, including the fine carvings in emeralds, jasper, granite, and porphyry. Among the uneducated classes of Peru

ANCIENT STUCCO WORK AT CHIMU CANCHU.

the idea exists that the ancients possessed the secret of softening stone by means of vegetable juices. The fact is that they succeeded, apparently without steel or iron, in doing with admirable perfection whatever they pleased with the hardest stone. Some writers have asserted that cement was used between the stones, but we have failed to find traces of anything of the sort.

As Humboldt says, "simplicity, symmetry, and solidity are the three characteristics that advantageously distinguish all the Peruvian edifices." The homes of the people were extremely simple. The rooms were few and had no communication with each other, each being provided with but one door, opening upon a courtyard or the street. There was no window or other aperture. The doorways did not exceed four feet in height and two in width, while in form they usually resembled those of Egyptian temples, being narrower at the lintel than at the threshold. The builders had most fantastic notions regarding doorways, for they made some narrower at the bottom than at the top, while others were shaped like jars of various forms. In the interior walls niches were made to serve as closets for domestic utensils. Beneath some floors there were cisterns shaped like conical jars, which served to store grain and other comestibles. The walls of the cisterns were smooth and hard; they had notches in which to set the feet in descending to the bottom of the granary, generally fifteen feet below the surface. The entrance was covered with a stone slab. Under the walls of some houses subterranean recesses have been found —the family ossuaries—filled with human bones.

GATEWAY OF INCA FORTRESS AT PLLANTAYTAMBO.

The palaces of the Incas and homes of the nobles were large and commodious, yet remarkably simple in their exterior construction, having no columns, cornices, or other ornamentation. Interiorly they were divided into large apartments and small chambers. The large rooms communicated one with another by intermediate doors and also, like the smaller ones, opened on a yard or a corridor that surrounded the building. Numerous windows afforded light and ventilation to the

large apartments. The walls were elaborately finished in polished marble and other stone, in some cases beautifully carved and decorated with ornaments of precious metal. Niches finished with fancy moldings were made to contain gold and silver figures of men and animals. In humbler dwellings the floor was merely leveled and stamped earth, but fine residences had marble floors of various colors, sometimes with thin plates of gold between the slabs. The doors of large houses gen-

INCA ROOF OF MOUNTAIN GRASS.

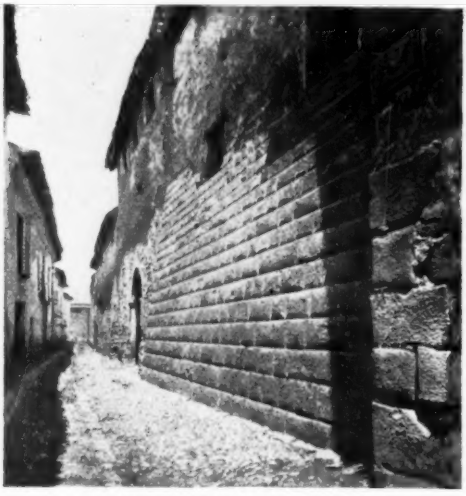
[The only specimen of this roofing now extant. Illustration from Markham's work.]

erally faced toward the east, were lofty and wide, and usually shaped like those of Egyptian temples.*

The lintels of Inca doorways were heavy timbers roughly squared,

*Modern researches are leading to the belief that the points of resemblance between Egyptian and Peruvian architecture were due to the fact that the builders of the two were kindred peoples. Dr. Le Plongeon is proposing to show, in a forthcoming book, that in remote times the Mayas—whose empire extended from the isthmus of Tehuantepec to that of Darien—were a colonizing and civilizing people, just as the English are to-day, who carried all over the earth their civilization, their sciences, arts, and traditions, which are found to have reached all the civilized nations of antiquity. They reached both Peru and Egypt. A. D. L.

or large slabs. Doorways were never arched, though the Peruvians knew how to construct an arch, as vestiges existing in several places show; while in the valley leading from Pachacamac to the Sierra there are small houses with domed roofs made of adobes, the semi-sphere being perfect. A distinctive feature of the Inca architecture was that the roof was always of a different material from the walls, being made of wood, straw, canes, or rushes. *Ichu*, or mountain grass, was most generally used. The only Inca roof remaining in a perfect state has a total thickness of five feet. The outer layer, two feet thick, was of grass, laid vertically with such regularity as to present a per-



WALL OF INCA PALACE AT CUZCO.
[With Spanish-arched Doorway.]

fectly-smooth surface to the weather. Next came a thick layer placed horizontally and matted together with reeds. The third and inner layer was placed vertically. The structure supporting this roof is called *sondor huasi*.

In the cities, houses adjoined each other, being built in continuous rows, forming long narrow streets which intersected at right angles. The outer walls were painted red, the general effect being somber and monotonous. The Inca buildings were remarkably spacious, their public edifices accommodating several thousand persons. The palace of Huayna Capac, the twelfth Inca, was eight hundred feet long. Incarial structures in general were square, oblong, and cyclopean, of

granite, porphyry, and other stone, laid in symmetrical and accurate courses. The walls, like those of adobes on the coast, were very thick at the base, decreasing gradually toward the top. Dr. Le Plongeon discovered that the large stones had been got into place by the united muscular strength of many men, working upon a series of inclined planes, with the aid of levers and wooden rollers.*

It is not possible to say what populations these ancient cities had, for the reason that, although the Incas kept a very correct census of their subjects, the Spaniards destroyed those records (*quipus*). The

AN INCA PORTAL AT CUZCO.

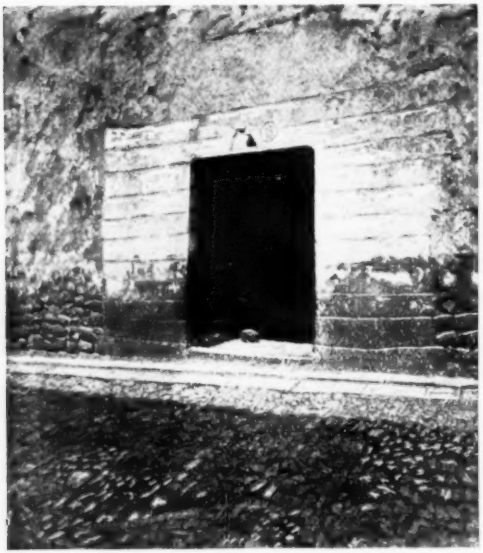
[A vestige of Manco Capac's Palace.]

city of Cuzco was not much more than a mile square, and its population is said to have been about sixty thousand.

On the southeast shore of Lake Titicaca, now Bolivian territory, once existed the city of Tiahuanuco. Not a building—nothing but one gateway—now remains standing, but the scattered stones excite profound admiration. Some are twenty-five feet broad, fourteen feet long, and 6½ feet thick; others are forty feet long. Here, in their eager search for gold, the Spaniards destroyed remarkable walls, blowing

* This conclusion, reached from an independent standpoint, is of interest as being in harmony with Mr. Durfee's accounts of ancient methods of moving heavy masses, in recent numbers of the Magazine.—THE EDITOR.

them up with gunpowder. The stones were as finely finished as a cabinet-maker might wish to see his wood. They were cut with alternate grooves and projections, like mortise and tenon, so as to fit into each other horizontally. Vertically they were held in position by round holes drilled in the top and bottom of each stone at exactly corresponding distances. It is supposed that short cylinders of bronze were placed in these. The stones were also held together with bronze clamps, of which vestiges have been found. The sides of the only remaining gateway at Tiahuanuco are absolutely perpendicular, like some of the Inca portals at Cuzco.



AN INCA PORTAL AT CUZCO.

The Incas had a very complete system of fortifications. A notable fortress was that at Sacsahuaman, near Cuzco. It was finished only a few years before the arrival of the Spaniards, by whom it was stupidly destroyed. The outer wall of the structure was eighteen hundred feet long, composed of massive blocks of blue limestone, put together in cyclopean style. Some measured twenty-seven by fourteen by twelve feet. The largest in the fortress has a weight computed at 361 tons. That fortress was connected with the palace at Cuzco by subterranean passages ingeniously constructed, four feet wide and six feet high, but at certain places so contracted as to allow only one man to pass, stooping between sharp-pointed stones that lined the passage. A few persons could have held such a spot against many invaders.

The Spaniards marvelled at the highways which they found in Peru. Whether these were the work of the Incas, as is commonly claimed, or of a much older people and only kept in repair by

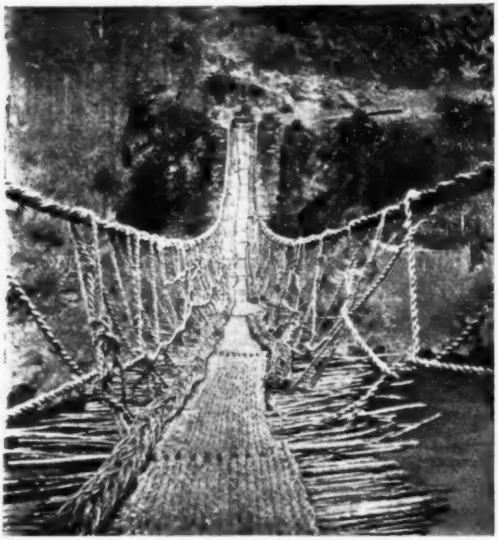
those wise potentates, is a question not easily decided. By means of galleries and tunnels many miles in length, cut through the living rock, the pedestrian passed high mountains, pathless, and buried beneath eternal snows. Dizzy heights were scaled by stairways hewn in the rocky mountains. The Spanish historian Gomara says that the two principal roads were each a thousand miles long. One that crossed the plain was twenty feet broad, walled on both sides, and had ditches on the outside, the whole way being shaded with cubeb-trees. The road over the mountain was twenty-five feet wide, cut in places through the solid rock, and in others made of stone and lime. These roads were level and went in a direct line, not deviating for mountain or lake. After the advent of the Spaniards no attempt was made to keep them in repair, although Pizarro said "nothing in Christendom equals the magnificence of these roads."

Hideous chasms were filled with solid masonry. Some roads were paved with flagstones, others with pebbles and a glutinous composition that made them resemble our macadamized ways, but perfectly smooth and almost as hard as marble. Pillars, like milestones, were placed at certain intervals, a little more than three miles apart. Bottomless abysses, rapid torrents, swift-running rivers, were crossed by suspension bridges constructed of ropes made of agave filament. Bridges of wood or stone were thrown across small streams, but great rivers had rope bridges. The simplest form was a single rope over which the voyager was conveyed in a basket. The natives yet make use of that method, which is common in Japan also. Across the river Pampas, in Peru, there is a rope bridge 135 feet long. That over the Apurimac, one of

PART OF FORTRESS AT SACSAHUAMAN.

the head waters of the Amazon, is 148 feet long, its lowest part being 118 feet from the water.

The Peruvian waterworks, whether constructed by the Incas or only kept in repair by them, are worthy of our notice. The Incas seem to have understood the law of fluids—known as equilibrium—their temples and palaces having been supplied through inverted siphons. Their system of irrigation was so complete that much of the now arid land was productive during the Inca period. The Spaniards destroyed part of the waterworks to possess themselves of silver pipes, and the rest have nearly all been suffered to fall to ruin. Stone canals, completely incased, were laid in the mountains, bringing streams of pure water to the cities. On the summit of the cordillera Dr. Le Plongeon followed the bed of one canal for a distance of fifteen miles on the slope of the Andes. Some of the canals yet exist; the valley of Nasca is watered by them and is surprisingly fertile.



ROPE BRIDGE, RIO PAMPAS, PERU.

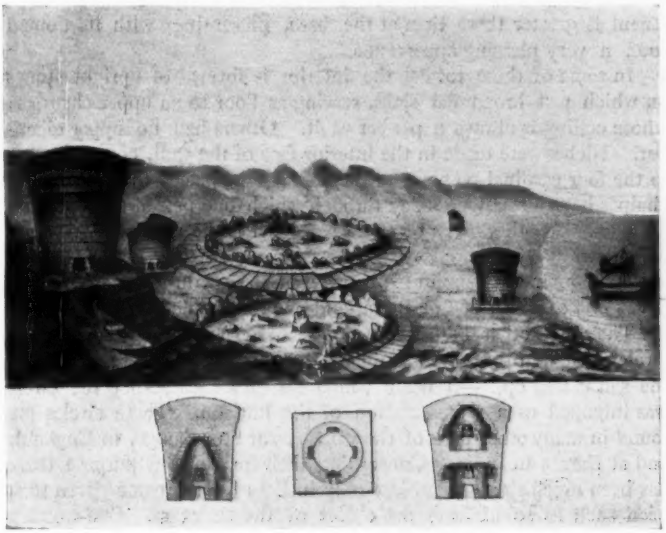
In the mountains are many thermal springs and near by them are found the remains of buildings. The fountain-beds were paved and sheltered beneath concrete domes, which were surmounted by figures of animals from whose mouths the water spouted, falling into gold basins through pipes of the same metal, thence into porphyry reservoirs.

Not less interesting than the deserted homes of the living are the resting-places of the dead, in many cases containing valuable articles of gold and silver and always some interesting objects that had belonged to those whose bodies were there entombed. All the great mounds on the coast are burial-places,—tombs piled one above another, in order

that the dead should cover as little ground as possible, leaving the soil for the maintenance of the living. The sacred city of Pachacamac (the Creator), a few leagues south of Lima, was a place of pilgrimage, and consequently the last resting-place of many thousands of human beings. The desert sands have covered half the city; that portion remaining has a boundary of four or five miles. The city wall, looming here and there above the sand, shows that it once inclosed a surface two or three miles square. The sepulchers of the Aymaras were truncated pyramids, twenty to thirty feet high. They placed their dead squatting in a circle. The mounds of the Changos were but eight feet high, interiorly. In these the bodies were laid straight out. The Quichua mounds were ellipsoidal and scarcely four feet high. The bodies placed within were seated with knees drawn up to the chin.

At Chimu Canchu, on the coast, some of the royal *huacas* or tombs were very extensive, consisting of several spacious rooms. Immense treasures were stored away with the dead kings; some of them have been found, while a continual search is being made for others.

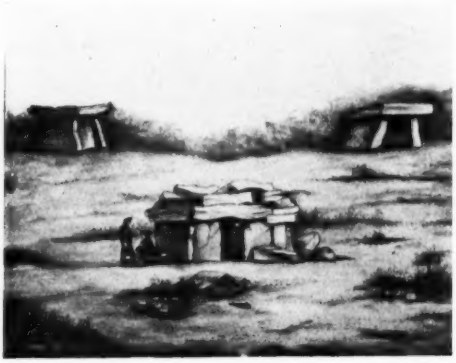
Except in unavoidable cases the Peruvians, owing to their enormous population, never deposited human remains in places that could be cultivated for agricultural purposes. They selected arid and



SUN-CIRCLES AND CHULPAS, WITH PLANS.

[From Sallustini, Lake Titicaca, Bolivia.]

sandy spots. Up in the cordilleras rock tombs are very numerous, and on the eastern slopes, from the brow of the mountains to the shores of Lake Titicaca, the tombs were of stone, the majority having the outward appearance of a mere square heap of unhewn stones. Some, called *chulpas*, near the shores of the lake, are circular towers, from ten to thirty feet high, their diameter increasing in proportion to their elevation. The stones forming the walls are cemented with tenacious clay. Their outer surface is curved to follow the line of the structure. The walls diverge toward the top, so that the diameter of the monument is greater there than at the base, presenting, with its domed roof, a very pleasing appearance.



KIT-KOTI. [From England.] PERUVIAN TOMB. [From Lake Titicaca.] TOMB. [From India.]

In some of these towers the interior is formed of upright stones on which rest broad flat slabs, serving as floor to an upper chamber, whose ceiling is always a perfect vault. Others had no upper chamber. Niches were made in the interior face of the wall, corresponding to the four cardinal points, and the bodies were placed therein. These chulpas have a small doorway through which one person can enter on all fours. Another form of stone sepulcher is the primitive structure which strikingly resembles the *kit-koti* found in the British islands; similar monuments exist in many parts of the earth. Our illustration shows one of Peru, one of India, and one of England.

The only other Peruvian structure to be mentioned is the sun-circle, called in the Quichua tongue *inti-huatana*,—"the place where the sun is tied up,"—a name which would indicate that the circle was intended as a representation of the horizon. These circles are found in many other parts of the world, as at Stonehenge, in England, and at Darab, in India. Concerning their origin and purpose there has been much speculation, but only in Peru has the name given to it been such as to indicate the object of the structure. Sun-worship existed in Peru, we are told, long before the Inca period; we may therefore safely regard the *inti-huatanas* as primitive sanctuaries.

THE ELECTRICAL TRANSMISSION OF INTELLIGENCE.

By Thomas D. Lockwood.

THERE can be no time more fitting than the present for a review of what has been done, and an attempted forecast of what yet remains to be done, in the electrical transmission of intelligence. The jubilee of the establishment of commercial telegraphy in America is close at hand, the first Morse line having been completed between Baltimore and Washington in May, 1844.

Telegraph lines were built and operated in Germany and England by Steinheil and Cooke & Wheatstone, respectively, before the construction of the first Morse line in America. It is noteworthy that the system of Steinheil comprised a magneto-electric sending generator, a capillary ink-writer and a conventional alphabet of dots, and that the Cooke & Wheatstone plan comprehended a current-reversing transmitting-key and a needle deflecting receiver, which indicated its messages by transient signals also formed from an arbitrary code and addressed to the eye alone.

The Morse system consisted of an electric circuit containing a battery, a key to make and break the circuit, and a receiving register which, by means of clock-work, advanced a strip of paper on which dots and dashes composing the characters of the Morse alphabet were embossed by a stylus actuated by an electro-magnet, in response to the operation of the key at the distant station.

In order that a relatively weak main-line current might be used, and battery-power economized, a fine wire receiving magnet called a relay, provided with a light and easily-moved armature, was placed in the main circuit to respond to the key; its function being to control by the movement of its armature between suitable stops or contacts, a short circuit in which flowed the much stronger current of a local battery, which circuit also included the magnet coils of the register. By employing this device the work of the main current was made easy and consisted in merely opening and closing a light supplementary key.

The story of the telegraph in America prior to 1866, when the scattered systems of the country coalesced into what is now the Western Union Telegraph Company, has no special interest for us to-day, and may be dismissed after brief notice. There had been no uniformity of practice in either construction or operation, and little material advance had been made save in the matter of physical expansion.

Though real advance prior to this time had been scant, invention had been prolific. The ingenious minds of a score of self-educated electricians had evolved as many forms of automatic repeater, by means of which, applying the principle of the relay, direct working might be effected between points too far distant to be connected by a single circuit, the sounder-lever of one line serving as the sending-key of the next. Reading the Morse code by sound had become universal, except in small country offices where students and neophytes were perennial. The House and Hughes type-printing telegraphs had waxed and waned: the Phelps combination printer, an instrument embodying the best features of both of its predecessors and combining them with new ones of its own, had come into extensive use on certain lines; and in New England the automatic chemical telegraph of Bain had evanescently atttempted to compete with the slower, but simpler and more trustworthy, key and sounder. Dial telegraphs, too, in which an electro-magnetically actuated pointer moved round a dial and spelled out words by halting an instant opposite the proper letters which were marked in a circle round the axis of the pointer, had to some extent been introduced in private telegraphs; and let it not be forgotten that one cable spanning the Atlantic had been successfully laid as early as 1858, and had lived and worked after a fashion for twenty-six days.

The history of the telegraph systems of foreign countries is not dissimilar. Reasons of the same character retarded their physical progression and at the same time stimulated invention, but the consummation in a majority of instances turned out to be State control instead of corporation consolidation.

Ocean telegraphy, regarded by many in 1865 as a veritable *ignis-fatüus*, has long been an accomplished fact; and communication between the old and new worlds, having been finally established in 1866, has ever since been maintained practically without interruption; the speed of transmission meanwhile having raised from ten to twenty-five words per minute. This achievement was no ordinary one, and is one of which the Anglo-Saxon race on both sides of the Atlantic may justly pride itself. Besides having proved an immense convenience in the transmission of intelligence generally, the successful establishment of transatlantic cable communication has revolutionized methods of business, and has imparted a celerity and directness to diplomacy well suited to American tastes and tendencies.

Perfect insulation in land lines, once practically ignored, is now universally regarded as one of the essentials of successful telegraphy,—at least in theory. We fear, however, that practice does not fully keep pace with conviction,—on the western side of the ocean, at any rate.

Marked improvement has been made in insulating media and compounds; and cable-manufacture, which is still practically a monopoly of the English, has reached the dignity of a fine art.

With the great influx of business everywhere attendant upon the increased popular acquaintance with the telegraph, and upon the growth of trade and commerce, came the vital question: How shall we get more work out of our wires? How best shall we work them up to their full capacity?

This has been answered in various ways. The duplex and quadruplex methods of transmission have been introduced, and have solved the problem in part by enabling a plurality of messages to be sent over one wire at the same time without interference. Multiplex telegraphs, operating by putting the same main conductors successively into contact with a number of independent terminals at both ends, have also come into use. The main difficulty in the way of employing these was that of keeping the transferring mechanism at the two ends synchronized; but this having been accomplished by Delany, the multiplex is being successfully operated in England. Wheatstone's automatic system answers the question in another way: by transmitting communications much faster, but in single file, over the same wire. In this system success has been reached by substituting for the electro-chemical receiver of Bain and others an electro-magnetic ink-writer. This automatic apparatus does excellent work in both England and America, especially in sending press matter, or where much of business is to be sent over a single wire; and under favorable conditions, and on lines which are not too long, it is capable of transmitting 600 words per minute.

Type-printing telegraphs are still extant, being employed in France, and on certain lines in the United States. The apparatus employed in the latter country is a highly-organized machine known as the Phelps electro-motor telegraph, in which the moving mechanism is actuated by an electro-motor, the principle of operation being the synchronous action of the transmitting shaft and type-wheel arbor. The type-printing telegraph is likewise utilized in distributing commercial and financial information to brokers and merchants in cities; a number of receiving instruments, popularly termed "tickers," being connected in serial circuit with a single central-station instrument, and placed in subscribers' offices.

Entering other fields of usefulness, the telegraph gives warning of our fires, summons our messengers, and informs us of burglarious visitations; the bye-uses of the telegraph are becoming constantly more numerous and important. One of the brightest signs of the times in telegraphy may be found in the universal recognition of the advantages of systematic electrical measurement and scientific testing, both for

maintenance and in the detection of faults, and in its well-nigh universal practice, which has indeed reached its apotheosis in the telegraph system of far-away India.

An important and valuable improvement is the employment of the dynamo for telegraphic circuits in many of our large cities. An advance equally important is the tendency towards the use of copper line wire.

We need scarcely look in the near future for radical and striking telegraphic inventions, but in view of past experience* we may reasonably expect a tremendous expansion in lines and business; a wider employment of the two last-named improvemants; a considerable increase in city underground work; the operation of longer individual circuits; far-reaching improvements in methods of collecting and delivering messages, perhaps by the increased employment of the pneumatic tube; additional speed in the operation of submarine cables; more press-matter transmission; and gradual changes in practice accruing from the introduction into the telegraphic service (which must ultimately open its ranks for their reception) of trained scientific electricians and engineers.

We hear constantly of the desirability of government ownership of telegraphs. To a candid and impartial thinker there is little in the idea which commends itself. Our party politics is still too unregenerate, and although the spoils system has sustained rude shocks, its spirit is still too rampant and aggressive to permit of a belief in the able, honest, and independent governmental control and management of such an engine, when manned and officered by the party happening to be in power. Things are better as they are, especially as telegraphy is low-priced, and as what we buy is really worth what we pay for it. Let us wait at least until politics is so purified, and technical administration so stable, that a change in party control involves no greater change in governmental machinery than a change of cabinet officers and their immediate assistants; and until competency and efficiency shall be universally held to constitute, for the working forces in all departments, a full and valid title to position, permanency, and preferment.

THE speaking telephone belongs to the history of our own times. In March, 1876, there was not a speaking telephone in the possession of the public and not a telephone line in existence. Yet telephonic transmission in eighteen short years, has brought into use in the United

* Between 1866 and 1892 the wire mileage of the Western Union Telegraph Company alone rose from 76,000 to 750,000 miles; its offices increased from 2000 to 20,000, and the yearly number of messages transmitted rose from 5,000,000 to 62,000,000. T. D. L.

States alone (in round numbers), 568,000 telephone transmitters and receivers, while the rest of the world employs about 580,000 more; and is furthermore to be credited with about 1,000,000 miles of telephone line wire, half of which, speaking broadly, is in the United States.

The telephone is like the telegraph in that the operation of both involves certain essential features: a source of electrical energy, a conductor through which this energy may travel from one point to another, and proper apparatus for delivering the message to the electrical messenger at one end of the conductor, and for enabling that messenger to tell the story at the other. But notwithstanding these similarities, telephonic and telegraphic transmission are things distant from one another, the former standing as completely alone and without peer as did Adam, among the four-footed associates of his garden, before the advent of Eve.

The relation of the telephone to the telegraph is that which the human voice, perfect in every articulation, bears to the deaf-and-dumb alphabet; and for this reason alone the achievement of the electrical transmission of speech must be regarded as the veritable capstone of the present century of discovery and invention.

The transmitter of the speaking telephone may be one which actually generates its own working currents in the act of transmitting speech, as in the magneto instrument; or it may be one which, as in the variable-resistance instrument, operates upon a current already provided—say by a battery—and which, in the act of transmitting, molds the ready-made current into the desired character. We may compare the action of the former to regulating the action of a steam-engine by generating more or less steam in the boiler, but admitting always such amount as is produced; and that of the latter to regulation by means of a throttle-valve, the original amount generated being always the same.

But whatever form of transmitter be employed two conditions must be observed: the transmitter, in order that it may exercise a constant control over the receiver, must have a circuit which is always unbroken, and the current flowing in this circuit must copy, electrically, the changes in the air produced by the spoken words in the vicinity of the transmitter.

It is not the number of vibrations per second, but the manner in which each is performed, that gives rise to the sensation of "quality," or the articulate character of sound. To transmit the "quality" and to reproduce the "form" of sound (which includes articulations), the transmitter must control the character as well as the frequency of the motions of the receiver. It can only do this by maintaining substan-

tially a continual control over the current by which it lays hold of the receiver; and the speaking telephone does this by using in the transmitter a device which makes the electrical changes copy those of the air in character as well as frequency, and, in the receiver, a device which makes the motion in turn a copy of the electrical changes in form and in character, as well as in frequency.

The telephone, though extremely simple in construction, has been very little changed by the years of experience which have passed since it was publicly introduced. But it has required or involved an immense amount of auxiliary invention and adaptation, and the telephone apparatus now in the hands of the user is a highly-organized combination of really independent devices, capable of exercising independent functions which have been added to the telephone proper to meet as many different contingencies.

In addition to the instruments actually used in talking and hearing, it involves an alternating-current generator to produce calling currents; a polarized bell to announce the call; a switch, acting by the removal and replacement of the receiver, to transfer the line between the call-bell and telephones, and to open or close the transmitter circuit; a battery to furnish the initial current which is to be acted upon by the transmitter, and an induction coil associated with the transmitter, serving as an electrical lever and giving the transmitter a wide range of resistance within which it may be effective.

The generator coil is also to be ordinarily shunted out of circuit to protect it from dangerous currents or discharges, and, when located at intermediate stations, to prevent it from opposing by self-induction the voice currents which otherwise would have to traverse its coils; to open this shunt circuit, a special circuit-breaker is required, for convenience arranged to be operated by the act of turning the crank to send the call.

The most modern telephone lines are built of metallic or two-wire circuits, and the two conductors are placed as close together as practical conditions will permit. The reason is twofold: the telephone current is the smallest current known which performs any useful effect, and an instrument responding to so feeble a current must be and is extremely sensitive. But, being so sensitive, it is very subject to be disturbed by stronger currents straying upon its circuit.

These stray currents sometimes come by way of the earth connections conductively, and of course cannot appear when a metallic circuit is employed; sometimes, however, they are induced within the telephone circuit by currents traversing neighboring circuits, and in that case the disturbance is quelled, not because the circuit is all of wire, but because its two wires are close together and joined at the

ends, so that the disturbing currents induced in the two wires, being of equal strength and of opposite direction in the telephone circuit, neutralize each other, leaving the telephones undisturbed.

Telephonic transmission is known to the world mainly through the telephone exchange; indeed, the public seem to have reached the conclusion that the telephone and telephone-exchange service are one and the same thing. It is evident that a telephone whereby I can communicate when I please with 5000 persons, and they with me, differs immeasurably from an exactly similar instrument which allows me to talk to but one or two particular persons only, and must be infinitely more valuable. It is also evident that in paying my exchange subscription I am not paying for a telephone, but for what I can get out of my telephone; for the economy of my time which it brings about; for the ability to find out whether the man I want to see is in, before I go to see him; for the hundreds of carfares and postage stamps I am saved from using; and for the convenience of talking to scores of persons without leaving my office,—no small convenience on a tempestuous day. Therefore not merely communication but intercommunication is the great field of force of the telephone, as is indeed manifested by the fact that nearly a thousand telephone exchanges are already in operation in the United States, and about as many more in other countries; and by the equally significant fact that 600,000,000 exchange-connections were made during the year 1892,—a number probably far exceeded in 1893.

The sub-station apparatus and the conductor of telephone-exchange circuits need not differ from those already described; but for the great business of the exchange—that of uniting lines for through conversation at the central station to which all lines converge—other appliances are required. These are combined mainly into a single instrumentality termed the "switchboard." By it calls can be received on annunciators and sent out by special generators; lines are united, conversation coached, and disconnecting signals received.

Each exchange line is fitted with one or more protective devices to forestall damage from electric-light or -power currents which may come on the telephone circuits by crosses with the conductors conveying them. In the great cities of the United States the telephone-exchange conductors, to a large extent, have been bunched in lead-covered cables and placed in underground conduits, there being at present some 350,000 miles of underground telephone wire in these cities.

Each cable conductor must be covered with some non-conductor throughout its length, and, as telegraphic and telephone currents inevitably travel with relative slowness and difficulty through subterranean

or subaqueous cables, by reason of the retarding effects of static induction, it is highly desirable to so construct the cables that they will retain, in the manner of a Leyden jar, as little of the working currents as possible. So much success has been attained in this line of work that the cables now made have but about one-third the objectionable retarding and distorting effect that they had eight years ago.

For long-line work copper wire has been found even more essential than in telegraphy, and every long-distance circuit, to work efficiently, must be a two-wire circuit, and its material must be copper.

The birth of commercial long-distance telephony goes back no farther than 1885, but lines have already united the cities of the Atlantic seaboard as far south as Washington and have reached the western cities of Chicago and Cincinnati.

An interesting phase of telephonic transmission is that, by making certain arrangements of circuits, condensers, and electro-magnetic resistances, it becomes possible to send telegraphic and telephonic messages simultaneously over the same lines. This has been done to a limited extent with success, and the possibilities in this direction, as well as in that of multiple telephony proper, are very promising.

It must be evident from this brief sketch that an enormous amount of inventive thought has been devoted to the improvement of the telephone and accessory apparatus. This is further emphasized by the fact that since 1876, when the first telephone patent was granted by the United States patent office, there have been issued (up to the beginning of the present year) 805 patents on speaking telephones, and 2235 patents relating to calls, systems, switches, special conductors, cables, and other telephonic appliances.

Such is the past of the telephone. We can but guess at its future. No doubt private lines with cheaply-made telephones will increase rapidly, and that the great mass of the people will become educated in the use of the telephone. In a few years, perhaps, we hope to be as familiar with duplex telephony as we now are with duplex telegraphy. The long-distance lines doubtless will continue in future, as in the past, to exert a salutary influence over local work, raising its character and improving its facilities. It probably will be found that there is plenty of room for both telegraph and telephone to work harmoniously side by side, and that the character of their business will be so dissimilar that each will feed the other.

The telephone will be extensively used in departments of work where it has, so far, merely dabbled in the shore waters, as it were, and will be increasingly employed in mining and diving operations. It will be utilized in the military and naval operations of the future, both in the transmission of conversation and as a telegraphic receiver,

in which latter capacity it will also be found generally acceptable. Perhaps it may find new fields of work in the permanent establishment of communication with moving trains, lighthouses, and even with vessels in mid-ocean; but so far as the last is concerned let us hope not, for that is now the only retreat from the cares of the world.

The hotel of the future will not be considered complete unless its rooms are provided with telephonic facilities for connecting them with each other, with the office, and with the outside world; factory systems arranged for the intercommunication of different departments will ere long be generally employed, and an office or a house fitted with a complete system of telephones will cease to be a rarity.

But telephonic transmission between London and New York, which some optimistic spirits are now discussing, I think will remain a subject for discussion only for many years to come, and need not be expected to reach fruition in time to be participated in by the writer or readers of this article on the electrical transmission of intelligence.

DEVELOPMENT OF THE INCANDESCENT ELECTRIC LAMP.

By John W. Howell.

THE incandescent lamp, though in such common use to-day, has been before the public only about fourteen years. The causes underlying the rapid growth in its use were the great demand for the light, which grew steadily as its peculiar advantages became better known, and the interest which was awakened in the minds of many workers by the problems which arose in great numbers in connection with the lamp itself and with the apparatus and appliances made necessary by its introduction into new fields. The development of incandescent lighting has called for the best efforts of master minds in many departments of scientific and technical investigation, and the attractiveness of the work has kept the interest of the workers keenly alive.

The incandescent lamp produces light without flame and with very little heat, with no consumption of oxygen or production of undesirable products, and with an utter disregard for surrounding conditions. These qualities render the incandescent lamp peculiarly suited for lighting very many places where other lights are inconvenient or dangerous. Thus it can be used in the presence of explosive gases or ignitable substances, as in coal-mines, oil-refineries, chemical works, and powder-mills. In cotton- and woolen-mills, and other factories where the product is at times in an easily ignitable condition, this lamp can be used in closer proximity to the work than can a flaming lamp.

The comparative absence of heat, besides being a blessing to all users in hot weather, is of special value to dentists and surgeons. The fact that the lamps consume no oxygen, thus yielding no disagreeable products, renders them peculiarly suitable for use on vessels where ventilation is often a difficult problem. Their adaptability is another cause of their popularity. The advent of these lamps has rendered artistic and decorative lighting possible. Who has not looked into a show-window lighted with concealed lamps and admired the effect? How many people have spent an hour in the dining-room at the Waldorf Hotel in New York without noticing that the candles on the tables were indeed candles, while the candles on the walls were miniature incandescent lamps?

People are so accustomed to the beautiful and wonderful adaptation of incandescent lamps that they evince surprise at nothing, and

satisfy their minds with the explanation that it is done by electricity,—a magic word that explains all mysteries and makes everything possible. It has indeed rendered possible many achievements impossible without it, but the work has been done by man, aided by electricity, and not by electricity aided by man. It is man's servant by conquest ; not nature's gift to the indolent.

Volta's discovery of the battery, in 1800, placed at man's disposal a new form of energy which at once received the attention of investigators. The transformation of electric energy to the other well-known forms was soon accomplished, and heat, light, and mechanical power were produced from electricity.

Sir Humphry Davy, in 1808, constructed a very large battery. In his experiments he produced the electric arc between carbon points and electrically heated to incandescence platinum and other wires, and carbon. The effects produced by the new and invisible form of energy were subjects of much investigation. Metallic wires and pieces of carbon were heated to incandescence in the open air, and in globes which were exhausted, or filled with different gases at various pressures.

Very early in the history of the subject we had in name, but in name only, all the elements which enter into the modern incandescent lamp. We had the carbon burner, the vacuum, and the glass globe with its leading-in conductors. While these elements existed in name in the apparatus made by Davy, they did not exist in the perfection necessary for a successful incandescent lamp. The best vacuum obtained at that time was not a vacuum in the sense in which the word is used in connection with incandescent lamps to-day. The globe which contained Davy's incandescent carbon was not suitable for the protection of a vacuum under the conditions of use as an incandescent lamp. The carbon conductors which Davy heated to incandescence would not have proved durable for any great length of time.

There are four essentials in the successful modern incandescent lamp: the vacuum, the glass globe, the carbon burner, and the conductors which carry the current through the globe. All these elements existed in name in the apparatus of Davy. The development of the lamp has not called for the discovery or introduction of any new element ; it is simply the development of the elements which existed in Davy's apparatus, and their arrangement in a combination in which the laws governing them and their relations to one another are appreciated and intelligently applied. The large batteries, which were the sources of the currents employed by Davy, were expensive to make and maintain, and were to be found only in a few large and well-equipped laboratories. Soon new forms of batteries were discovered, and the

magneto-electric machine was invented, cheapening the production of currents.

Practical and commercial applications of the new phenomena are the subjects of the patents which form so large a part of the records of the history of electric-lighting. From the lamp patented by Starr in 1845 to the lamp of Sawyer and Man in 1879 very little progress was made toward the final solution of the problem, except in the carbon burner. The extreme simplicity which characterizes the modern incandescent lamp, and to which its success was largely due, was more nearly approached in the Starr lamp than in many subsequent lamps.

Starr's lamp is worthy of special attention. The carbon burner was contained in a bulb blown on the end of a barometer-tube. This bulb and tube were filled with mercury, and air and moisture were driven out as was done in making barometers. The tube was then inverted in a cup of mercury, leaving a Torricellian vacuum in the bulb at the top of the tube. One of the conductors which carried the current to the burner was a platinum wire sealed in the top of the bulb by fusion of the glass. The other conductor was a wire which dipped into the mercury in the tube. The support for the burner was a simple piece of insulating material.

Let us study in this lamp the four elements whose development we are tracing. The carbon burner was made of gas-retort carbon, which, although difficult to make into thin pieces, is a very hard and dense carbon. It was the best carbon known to the art at that time; indeed, its nature is similar to that of the carbon deposited on modern filaments by the hydrocarbon treatment. The glass bulb was a simple one. It was made of thin glass, which was advantageous. The open end was closed by mercury more tightly than many subsequent lamps were closed. The one platinum conductor which was sealed in the glass illustrates the method of carrying the current into the lamp which is in almost universal use to-day.

The Torricellian vacuum in this lamp was at that time considered a perfect vacuum, and was a practically good vacuum until the lamp was operated. But when the lamp was burned gases were driven by the heat from the interior parts of the lamp, which impaired the vacuum and soon rendered the lamp useless. The lamp, when in use, was still attached to the barometric tube by means of which it had been exhausted, and when the lamp was operated the depression of the mercury in this tube showed that gases were liberated within the lamp. This was a fatal defect, and the method of exhausting offered no remedy for it. Modern lamps are exhausted by means of vacuum-pumps which draw from the lamp-chambers all air and other gases. When the air has been withdrawn, the lamps, being still connected

with the pumps, are burned, and the gases, liberated by the heat, are drawn from them by the pumps.

The difficulty of producing a vacuum good enough to render carbon stable at a high incandescence caused many inventors to prefer platinum as the material from which to make the burners of their lamps. It also led to the invention of several lamps in which the carbon, when consumed by the air necessarily remaining in the lamp, was replaced automatically by another. Some of these lamps had several carbons. The lamp patented by Konn in 1875 was of this type, and was probably the most successful lamp made up to that time. It had five carbons. This lamp had a limited commercial use. The first carbon was consumed almost immediately when put in use, and each subsequent carbon lasted about two hours. The mechanism in these lamps increased the amount of gas liberated in the lamp by the heat, and increased the difficulty it was intended to remedy.

The consumption of carbon in the best vacuum that could be produced led many inventors to fill lamp-chambers with a gas which would not combine with the incandescent carbon. The lamps made by Sawyer and Man in 1879 were filled with nitrogen gas. These lamps, during the process of filling, were burned, while this gas was passed in a stream through them, and the gases liberated in the interior of the lamps by the heat were thus washed out and the lamp-chamber left full of nitrogen. The heat-conducting power of this gas caused these lamps to get heated, and means of cooling them had to be found.

Every lamp before 1878 was made in separate parts. This construction was made necessary by the short life of the burners, which necessitated their frequent removal, and by the liability of the mechanism to get out of order. The parts of these lamps were cemented and clamped together, and methods of making such joints tight were subjects of invention. Before this time pumps had been invented which were capable of producing a nearly perfect vacuum, but incandescent-lamp inventors had not availed themselves of them.

The best lamps produced up to 1879 had two features which rendered them unsuited to the maintenance of a high vacuum. The large amount of mechanism which they contained would liberate gases when the lamps was burned; and the joints between the separable parts of the lamp were almost of necessity a source of trouble from leakage, as it was difficult to make such joints tight in a structure which was heated and cooled frequently. Thus the two lines which had been followed by inventors in their efforts to remedy the evil effects of an insufficient vacuum had removed the lamp-chambers further and further from the simple all-glass bulb which characterizes the successful lamp of to-day.

When we consider that all inventors, whether they used a series of burners or one burner in a lamp having a vacuum or containing an inert gas, recognized the necessity of making the lamps in separable parts, we admire the boldness of Mr. Edison in reducing the lamp to elementary simplicity, putting inside the lamps nothing but the carbon burner and short conducting wires, and making the chamber entirely of glass sealed at all points by fusion. Such a lamp-chamber would maintain a vacuum. There is no joint in this lamp at which leakage can occur, and the leading-in conductors are sealed into the glass so that no leakage can occur where they enter. They cannot be taken apart to put in new burners; consequently they must burn so long that when they do break the user is satisfied to throw them away.

Having traced the development of the lamp-chamber, let us consider the carbon burner. The early experimenters naturally used pieces of charcoal, which was readily consumed, as it oxidizes at a low temperature. Pieces of gas-retort carbon were found to be more durable, and Starr used the latter in his lamp. It is hard to work to the desired size, but is denser and harder than charcoal and requires a higher temperature to oxidize it. The difficulty of making these burners led experimenters to devise methods of making artificial burners. In 1857 Charles W. Harrison made carbon burners by suspending pencils of charcoal in a retort which was filled with gas and heated to a high heat. This deposited a layer of gas carbon on the charcoal, which made it very hard. This process was also used by Sidot in 1870 and by Gaudoin in 1877. Gaudoin also made carbon burners by carbonizing pieces of wood of the shape and size desired, which were soaked in syrup, and recarbonized, several times. Carré, in 1876, made carbon rods and pencils by grinding different kinds of carbon together, mixing with syrup, molding and baking. He baked these carbon rods several times, soaking them in hot syrup before each baking. In 1879 Sawyer and Man immersed their carbon burners in a "carbon liquid" and heated them electrically while so immersed. This process deposits upon the burner a layer of very hard carbon. This is the best method known for making burners for incandescent lamps, and nearly all burners used to-day are finished by this process. The carbon burners used to-day upon which this treatment is applied are chiefly made of (1) silk threads, treated to harden them; (2) bamboo cut to the desired size; or (3) cellulose, which is dissolved, treated chemically, and made into pieces of the desired size. Each of these materials must be reduced to carbon by baking at a high temperature. The advantage which one of these may have over another lies in their adaptability and the ease with which they may be made of the desired size. Many filaments used to-day are

only five one-thousandths of an inch in diameter, and to make such filaments in large quantities requires a base material which is homogeneous, and which can be conveniently carried through the necessary processes of manufacture. Filaments made of chemically-prepared cellulose, or of bamboo, have been used with fair success without being treated by the carbon-depositing process, but this process is necessary to secure the best results from any carbon base.

This process is beneficial in three ways: it coats the base with a layer of very hard, dense, and stable carbon; it brings all the burners to a predetermined resistance, and it deposits gray carbon, which is a worse radiator of heat than is any other form of carbon which has been used for filaments of incandescent lamps.

The amount of light which a given burner yields in an incandescent lamp depends upon its temperature. The efficiency of the lamp depends upon the amount of energy which must be constantly supplied to the burner to maintain its temperature. The worse the heat radiating power of any burner, the less rapidly it is cooled by radiation, and the less the energy necessary to maintain its temperature or candle-power, as the energy supplied must equal the energy dissipated. The efficiency of a given burner depends upon the amount of surface which yields each unit of light,—the greater the surface per unit of light the less the efficiency.

Consider two burners of the same size, one having been treated and the other not. The treated burner, being the worse radiator, will yield a given amount of light with less energy or at a greater efficiency than the non-treated one. Consequently, if a treated and an untreated burner are to be made of the same candle power and efficiency, the treated burner must have a larger surface than the untreated one. Assuming that two burners are at the same temperature when they are yielding the same amount of light per unit of surface, we conclude that a treated burner is operated at a lower temperature than an untreated one at the same efficiency. And, being at a lower temperature, it should give a longer life, be more stable, and maintain its candle-power better. Thus the hydrocarbon treatment increases the stability of a burner by reason of the character of the surface which it gives, as well as by the hardness and density of the deposited carbon.

This deposited carbon has a much lower specific resistance than any other form of carbon available for incandescent-lamp filaments. This is a great advantage in making low-resistance burners and a disadvantage in making high-resistance ones.

The inventor of the hydrocarbon-treatment process did not understand that a bad radiating surface was desirable, but urged the good

radiating power of carbon as one of its advantages over platinum. In 1879, Alfred Niaudet, a French phycisist of deservedly high repute, compared the radiating power of carbon and platinum, to the detriment of the latter, for use in incandescent lamps. In 1874, Wild, the director of the Russian imperial observatory, made the same comparison and drew the same conclusion. Exactly the opposite is the fact. If a stable coating of bright platinum could be applied to a carbon burner, it would be better in this respect than the coating given by the hydrocarbon treatment.

Thus far we have considered the incandescent lamp as an apparatus for converting electricity into light, without any reference to its relation to the system of distribution by which the lamps are supplied with current. With the exception of Lane Fox, no inventor of lamps prior to Edison appears to have considered the qualities which successful distribution require in a lamp. No carbon-burner lamp, before Edison made his, had that characteristic so essential to multiple-arc distribution,—namely, high resistance. The lines along which inventors previous to Edison had traveled precluded the possibility of their making high-resistance carbon-burner lamps. No lamp-chamber used by them was capable of successfully maintaining the high vacuum necessary to render filamentary high-resistance burners stable. The short, thick carbon burners which they used wasted away quite rapidly, and certainly a filamentary burner would have been consumed in a short time. Reasoning with a knowledge of the performance of lamps previous to Edison's, any one would be justified in pronouncing a filamentary burner a probable failure. Indeed, Edison's filamentary burner was made possible by Edison's all-glass lamp-chamber. There was practically no superfluous material in it to give off gases. Being closed at all points by the fusion of the glass, it would protect a vacuum indefinitely, and the duration of the lamp in use was limited by the stability of the carbon burner. The tendency of invention from Starr to Sawyer and Man had been to fill the lamp-chamber with mechanism. Edison went directly to the root of the matter, stripping the lamp of all unessential parts. The lamp made by Edison in 1880 and the lamp made to-day are different in details of manufacture only. Their appearance and general characteristics are the same.

An incandescent lamp is simply an apparatus for converting electricity into light. The laws which govern the lamp are the well-known laws of heat, light, and electricity. No new law has been discovered in connection with incandescent lamps. Edison was, I believe, the first to correlate these laws, and to make a lamp which, because of its harmony with these laws, was stable.

The multiple-arc system of distribution is the ideal one for oper-

ating incandescent lamps. It was by making his lamp of such high resistance and such small radiating surface that it could be used on such a system that Edison made his lamp a commercial success. But if we consider the lamp without any reference to any system of distribution, a very high-resistance lamp is inferior to one of lower resistance. The systems of distribution in general use to-day use lamps of two general voltages—115 and 55. The 115-volt lamps are of very high resistance. The 55-volt lamps are of lower resistance, and are superior to the 115-volt lamps. When this fact is more fully appreciated, lower-voltage lamps will be more generally used. By using lower-voltage lamps we can get the benefit of the advantages of the increased stability which these lamps have, and this will enable us to use lamps of fewer watts per candle than are required by the higher-voltage lamps.

The greatest development of the lamp since 1880 has been in its efficiency. The first lamps commercially installed by the Edison company required 6 watts per candle to operate them, whereas now well-regulated stations use lamps requiring only 3 watts per candle; thus each horse-power produces twice as much light now as it could have produced in 1880. Progress is still being made in this direction. Every improvement in the quality of a lamp allows it to be operated at a higher efficiency, and it is in this direction that we look for future improvements.

THE PYRITIC-SMELTING PROCESS.

By Philip Argall, E. M.

THE greater part of the precious metals produced in the western United States are extracted from their ores by the smelting process, in which base metals are the vehicles used to collect the gold and silver contents of the ores and concentrate them in metallic lead, in a copper-matte, and sometimes in an iron-matte. The method of smelting employed in each particular case usually derives its name from the base metal used, or from the particular ore employed in the process of reduction; we have, therefore, so-called lead-smelters, copper-smelters, iron-matte-, and pyritic-smelters, though the principal object in each process is the extraction of the precious metals contained in the ores.

The Omaha and Grant Smelting Works at Denver, Colorado, may be taken as a typical example of a lead-smelter,* combining all the recent improvements. The output from these works for the year 1893 was: Lead, 20,865 tons; copper, 481 tons; gold, 90,213 ounces; and silver, 10,059,711 ounces, having a total value of $11,917,828. Now the value of the lead in this output is but $1,441,000, from which it appears that, for each dollar's worth of lead produced, over six-and-a-half dollars' worth of precious metals were unlocked from the ores and started on their mission of usefulness to mankind.

The Boston and Colorado Smelting Works, also at Denver, is probably the best example of a copper-smelter in the sense used in this article. The output from these works during 1893 amounted as follows: Copper, 5357 tons; gold, 61,102 ounces; and silver, 4,177,117 ounces, having a total value of $5,607,186. Of this amount but $1,071,478 was derived from the copper or base metal used to collect the gold and silver from the ores. Here, then, we see that each dollar's worth of copper produced gave an accompanying value of nearly $4.50 worth of precious metals.

Iron-matte smelting, or the reduction of raw or partly-calcined sulphid ores for the purpose of collecting the precious metals in an iron-matte, though not much practised in the west, has been conducted at various European works from a very early date. The German authorities show that one Barthel Köhler used this system of smelting at Freiberg as early as 1585. Dr. Percy, in his metallurgy of gold and silver, makes special mention of iron-matte smelting, and he shows that it is

*For a description of the usual lead-smelting process, see the very interesting article by Mr. Walter Renton Ingalls in the March number of this Magazine. P. A.

specially adapted to localities in which lead-ores are not procurable at a sufficiently low rate to justify lead-smelting. Such are the conditions that obtain at the famous Kongsberg mines, in Norway, and there iron-pyrite has long been employed in smelting the ores. It is added to the furnace charge to the amount of 15 per cent. of the ore smelted and serves to collect the silver in an iron-matte, which subsequently is desilverized by means of lead. The furnaces used at Kongsberg prior to 1847 had a capacity of only ten tons of charge per day. The pressure of the blast used was one-sixth of a pound per square inch, and the consumption of fuel in the furnace about 22 per cent. of the weight of the charge, the fuel being fir and pine charcoal. Iron-matte smelting has long been practiced at Sala, in Sweden, in Hungary, the Altai mountains in Russia, and in various other parts of Europe.

The first step in the Swansea method of copper-smelting is the production of a copper-matte, or copper-iron-matte, in reverberatory furnaces, from the partially-roasted ores. This is the method pursued today at the Boston and Colorado works, already referred to as a copper-smelter. It will be seen that in all these matte-smelting methods, both for iron- and copper-matte, the ores, if sulphids, are first calcined to drive off the excess of sulphur, or, if not sulphids, then sulphur is added, usually in the form of pyrite (as in the Kongsberg practice, for example), in such proportion that the resulting matte shall form but a small part of the total product of the furnace,—say 5 to 15 per cent. of the ore smelted. In this way the precious metals distributed in the ores become concentrated in an iron- or copper-matte. When sulphid ores are to be reduced by the lead-smelting process, they are first calcined to drive off the sulphur, and thus convert the sulphids of the metals into oxids.

Pyritic-smelting, briefly, is iron-matte smelting in blast-furnaces, but it differs from the ordinary matte-smelting in the fact that, in the latter, no attempt is made to utilize the calorific properties of the ores, while in the former the aim is to perform the entire smelting operation in the furnace by means of the heat evolved from the combustion of the sulphids. To the lead- and copper-smelter, pyrites and other natural sulphids are not the most desirable ores, though valuable, it is true, for their iron contents, but nevertheless requiring calcination before they can be smelted, and therefore demanding a more expensive treatment, which often results in a greater loss of precious metals than occurs in the smelting of oxidized ores.

To the pyritic smelter, however, natural sulphids, particularly iron-pyrites, are not only docile ores, but are also *fuel*, capable of being consumed in the furnace, smelting not only themselves, but also the fluxes necessary to form a slag of the desired composition. Pyritic-

smelting, then, is intended to be a process of smelting without the use of carbonaceous fuel in the furnace. This at first blush seems impossible, and, though a theoretical examination of the process shows that it should easily be accomplished, yet in practice a small amount of fuel is often found necessary, particularly where the ores are not of the proper composition and character to give the best results.

It may not be generally known that pyrite can be burned in very much the same way as coal or other fuel, and that, when consumed under proper conditions, it can develop a temperature very little less than that produced by the best coal. Some persons who are, or should be, familiar with the combustion of pyrite assume that all the heat is derived from the sulphur. This is an error. The calorific power of 1 gram of mono-sulphid of iron, Fe S, is, neglecting that absorbed by the dissociation of the elements, about 1621 thermal units, of which 807 are evolved by the combustion of the sulphur, and 814 by that of the iron. The temperature produced by the combustion of mono-sulphid of iron is shown by calculation to be about 2200° C. Sulphid of zinc gives a temperature of about 2000° C.; lead sulphid, 1860° C.; while coal, containing 80 per cent. of carbon, 5 per cent. of hydrogen, and 15 per cent. of noncombustible matter, gives a combustion temperature of about 2700° C. It is important, however, to note that, while the combustion of coal apparently produces a higher temperature, in reality the sulphid of iron does more work in the furnace, for in the first case much of the heat produced is absorbed in expanding the gaseous products of combustion and associated nitrogen, whereas, in the case of sulphid of iron, the resultant product being mainly protoxid of iron, the heat generated is applied to a more essential purpose, the smelting of the ore. These facts are easily demonstrated by a calorific calculation, which the limits of this article will not permit.

It follows, then, that for metallurgical purposes these sulphids, particularly pyrite, can be made to act as fuel when the proper conditions for their thorough combustion exist in the furnace. Pyrite will burn under the ordinary atmospheric conditions, and give out considerable heat. The heap-roasting of pyritic ores is a familiar example. This process is conducted on an extensive scale at Sudbury, Canada, where large heaps of the niccoliferous pyrrhotite are set on fire, and burn for considerable time, the object being to drive off the sulphur and prepare the ore for the subsequent smelting operation. At the pyrite-mines in Spain heaps of many thousand tons are set on fire and burn for a period of five or six months, with the evolution of immense quantities of sulphurous-acid gas. This practice will, however, with the introduction of pyritic-smelting, be relegated to the oblivion of the barbaric methods of metallurgy. For apart from the destruction of

valuable fuel and the locking up of large stocks of ores for long periods of time, it also results in destroying the vegetation and soil, producing a general appearance of desolation and decay in the neighborhood of the works.

Another familiar example is the burning of pyrite in kilns for the manufacture of sulphuric acid from the gases given off. In these kilns the pyrite is burnt at a cherry-red heat at the rate of about forty pounds per square foot of grate-area, or, say fifty square feet of grate-area per ton of ore burnt per day. A modern pyritic-smelting furnace would easily consume 100 tons of pyrites per day in the same area. Now as temperature is, within certain limits, directly proportional to the amount of fuel consumed on a given area in a given time, one will readily see, by analogy, the enormous temperature that can be produced by the oxidation of pyrite in such quantities. In this way, the possibility of pyritic-smelting becomes manifest even to the uninitiated.

From an examination of the available literature of the subject I am led to the conclusion that the inception of smelting pyrite by its own combustion came long after Bessemer's invention for the direct manufacture of steel, by means of blowing air, divided into numerous jets, through a bath of molten cast-iron, thus effecting the rapid oxidation, or combustion, of carbon, silicon, and certain other substances present in pig-iron. In this process it is obvious that the high temperature developed in the converter is the result of the intimate contact between the air and various oxidizable bodies present. To substitute a molten copper-iron-matte in the converter for the cast-iron, and to oxidize the iron and sulphur of the matte, producing "black copper" in one operation, would appear to be a natural development of the Bessemer idea, and one that, at the first glance, appears to be very easily carried out. Nevertheless, the first experiments in this direction, made in Russia in 1867, resulted in complete failure, as did also the attempts of Mr. John Hollway to smelt pyrite in a modified Bessemer converter, in England, in 1879. M. Pierre Manhès, however, in 1881, succeeded in the bessemerizing of copper-matte, overcoming the difficulties of the earlier experimenters, and established his process on a working basis in France. This Manhès process, with various modifications and improvements, is now very extensively used in this country for the treatment of copper-mattes—of low contents in precious metals. I look upon the Manhès process as pyritic-smelting carried to a conclusion by the more or less complete oxidization of the iron and sulphur, and the production of almost pure copper (98 to 99 per cent. fine) from the ordinary copper-matte.

Returning to pyritic-smelting proper, the experiments of Hollway

proved that it was possible to smelt pyrite by means of the heat developed through its own combustion. But many obstacles and difficulties were encountered, some of which proved insurmountable, and in consequence of which continuous smelting could not be carried out in the apparatus then used. And while the experiments excited much interest at the time, it was generally conceded that as a commercial system of ore-reduction the whole process was a failure.

Mr. W. L. Austin, of Denver, for some years past has given this subject of pyritic-smelting much thought and attention, subjecting his methods to careful and thorough tests on a working scale, until he has succeeded finally in overcoming the difficulties encountered by the earlier workers in this field, and, with the aid of the most modern improvements in metallurgy, has built up a system of pyritic-smelting that has taken firm root in Colorado, and has become a great industry in the land.

The furnaces used in carrying out the Austin system of pyritic-smelting closely resemble the blast-furnace used in lead-smelting; differing, however, in some essential particulars which are necessary to fit it for the use of the sulphids as fuel instead of the carbonaceous material employed in the lead-furnace. The capacity of the pyritic furnace is, however, from 30 to 50 per cent. greater than that of a lead-smelting furnace of the same dimensions. This may be partly explained by the fact that in the former the ore and fuel are united in the one substance, *pyrite;* consequently no space is occupied with coke, nor is any time wasted in burning this bulky material.

The *modus operandi* of a pyritic furnace consists in feeding the raw ores and fluxes in pieces as large as can be conveniently handled —and of course, of the proper composition to form the desired slag— and drawing off the products of the smelting operation, matte and slag, either continuously, as in the case of large furnaces, or at regular intervals in the case of smaller ones. The matte resulting from the first smelting is usually put through the furnace again, together with rich silicious ores. This matte is, if anything, a better fuel than the raw pyrite, and by this second process it is concentrated to a very high value in precious metals, and is then shipped to the refiners. It is, of course, understood that the raw, unroasted pyritic ores are used in the pyritic-smelting furnace, while in other smelting processes such ores must be calcined—often at great expense—before they can be smelted. In the pyritic process, then, the ores are, as it were, roasted and smelted in one operation, at a cost very little in excess of roasting the ores by hand labor.

A word explanatory of the theory of this interesting system of smelting may be permissible. As the pyrite, $Fe\ S_2$, descends the shaft

of the furnace, one atom of the sulphur is expelled when the zone of dull-red heat is reached. This atom, on meeting the air at the surface of the charge, burns, with the characteristic sulphur flame, to sulphurous acid, $S O_2$. The pyrite, then, deprived of its extra atom of sulphur, reaches the zone of fusion as mono-sulphid of iron, Fe S, and here it is immediately oxidized by the highly heated air-blast to ferrous oxid and sulphurous acid. The former, combining with the silica, forms a slag of ferrous silicate, while the latter ascends the stack with the other gases. As there is always more mono-sulphid present than can be oxidized by the blast, the sulphur runs down in the form of iron-matte, which contains practically all the precious metals carried in the furnace charge. If the furnace is worked with a closed top, sulphuric acid can be manufactured as a by-product from the gases evolved from the smelting operation.

In lead- or copper-smelting, ores rich in these metals are smelted for a moderate price per ton, while the ores that require the addition of lead or copper to the furnace charge, in order to beneficiate them, are naturally subject to a much higher rate of treatment. The supply of such ores in Colorado has been for some time in excess of the available quantity of lead- and copper-ores necessary to treat them. Leadville, for example, for many years the center of the lead-smelting industry, and even now the greatest producer of lead-fluxing ores in this country, did not yield sufficient lead last year to treat more than one-half her own output. It would therefore appear that there is a good opening in Colorado for a smelting system that can reduce "dry" ores without lead or copper, or with but little copper. Such a system is found in pyritic-smelting, by which the precious metals are reduced from their ores by means of the very common, cheap, but nevertheless useful, metal, *iron*.

Pyritic-smelting is not only applicable to the reduction of the ores of the precious metals, but it can also be applied to the treatment of niccoliferous pyrrhotite, or cupreous pyrite. The raw ores in each case would be fed direct to the furnaces together with the necessary fluxes, the resulting matte could be drawn off into converters and blown until the desired concentration is reached. The whole process of making black copper from the ores should not, under favorable conditions, and conducted on a large scale, exceed $2.50 to $3 per ton of ore treated.

Pyritic-smelting is comparatively new in Colorado. It is just two years since it was introduced at the La Plata smelter at Leadville, yet we find two works running under this system last year, treating, according to the published statements, over 55,000 tons of ore, producing therefrom 494 tons of copper, 6165 ounces of gold, and 1,224,026

ounces of silver. The product of these works is, as we have seen, an iron-matte containing some copper. Now, as the iron in the matte is of little commercial value, it is not estimated in the yearly statement. Taking the copper for comparison, however, we find that, for each dollar's worth of this metal produced, over $11 worth of precious metals were collected from their ores, against 6½ to 1 in the typical lead-smelting example, and 4½ to 1 in the copper-smelting example given herein.

A process that can obtain such remarkable results within two years of its introduction into a state that holds the proud position of leading the world in the metallurgy of the precious metals, shows at once its great metallurgical value as well as its economic importance. And it augurs well for its successful introduction into other countries less highly favored with smelting-works than Colorado, but which have more extensive deposits of available metallurgical fuel in the form of pyrite. This ore occurs in almost every mineral vein, is more or less abundant in every country, and is now through this process rendered valuable, both as a fuel and as a vehicle for smelting and collecting the precious metals from their ores.

THE BEET-SUGAR INDUSTRY IN THE UNITED STATES.

By Harvey W. Wiley.

THE beet-sugar industry in the United States is in its infancy, there being only seven manufactories of this product in operation in the country. The oldest of these, at Alvarado, California, was erected about fifteen years ago and has been operated every year since. The factories next in order in seniority are those at Grand Island, Nebraska, and Watsonville, California. Still younger than these, by one year, are the factories at Norfolk, Nebraska; Lehigh, Utah; and Chino, California. The youngest and smallest of the factories, located at Staunton, Virginia, has been operated only one season. The increase in the rate of beet-sugar production in the United States during the past few years is shown as follows:

	Pounds.
In 1887	600,000
In 1888	4,000 000
In 1889	6,000,000
In 1890	8,000,000
In 1891	12,004,838
In 1892	27,083,288
In 1893	43,648,797

The next table gives the production, during 1893, at the different factories, as follows:

	Pounds.
Staunton, Virginia	36,458
Grand Island, Nebraska	1,835,900
Lehigh, Utah	3,750,000
Norfolk, Nebraska	4,000,000
Alvarado, California	4,186,572
Watsonville, California	14,500,000
Chino, California	15,039,867

The amount of capital invested in the seven beet-sugar factories is about $2,000,000. Tributary to these factories, under cultivation in beets, are about 20,000 acres of land. The value of this land has greatly increased since it has been used for beet-growing, especially near Chino, California, where the price per acre has become very high, as much as $200 having been paid in some cases. The cost of cultivating this land in beets is considerably more than $500,000 a year. The production of beet-roots for sugar-making purposes in the United States during the past year approximated 200,000 tons, and the average price paid to the farmers for this raw material was $4.50 per ton.

It will be seen that a large investment of capital in land and machinery and a large outlay of money for labor are needed to produce a little over 20,000 tons of sugar per year. It is not difficult to foresee the large amount of capital that would be absorbed, the immense amount of labor that would be employed, and the great extent of land that would be placed under cultivation, if even half of the sugar consumed in the United States were made from beets grown within the country. The yearly consumption of sugar in the United States is now approximately 2,000,000 short tons, while the total production of all kinds of sugar—beet-root, cane, maple, and sorghum—is about 300,000 short tons, showing that a little less than one-sixth of the total amount consumed is produced at home.

The manufacture of beet-sugar in this country is a matter for serious consideration. By reason of the restricted area suitable for the cultivation of sugar-cane it is not to be expected that, under the most favorable conditions, the production of cane-sugar in Louisiana, Texas, and Florida will ever largely exceed 1,000,000 tons. On the other hand, there are no limits to the possible amount of beet-sugar which can be manufactured.

THE SUGAR BEET.

The production of sugar-beets is of itself an art. The ordinary forms of agriculture cannot be used for this purpose. Sugar-beet culture is in every sense intensive, and not extensive, farming. High-priced lands can be used for sugar-beet culture on which it would be impossible to grow profitably the staple crops. Intensive culture, high

FIELD OF SUGAR-BEETS—CULTIVATING AND CLEARING.

fertilization, and scientific care in every respect characterize successful beet-sugar culture the world over. The sugar-beet requires a deep mellow soil, perfect tilth, entire freedom from weeds and grass, and a great deal of hand-culture. The sugar-beet absorbs large quantities of water in its growth; it is fond of potash and phosphoric acid, and is not averse to nitrogen. It is a crop which should not be grown more than once in four years upon the same field, and this field, by judicious rotation and fertilization, is brought during this time into perfect condition again for the production of a maximum crop of beets. The establishment of beet-sugar culture in a community gives an object-lesson in the highest art of agriculture. It acts reflexively upon every other branch of agriculture, so that in countries which grow sugar-beets there are better crops of wheat and maize, of barley and hay; there are better classes of live stock, finer horses and cattle, and in general the whole tone and character of agriculture are elevated by reason of the influence, direct and reflexive, of the culture of the sugar-beet.

The sugar-beet has been brought to its present state of efficiency by the application of scientific principles of culture in the production of seed. The mother beets selected for seed the previous year are chosen on account of their perfect form and size. They are preserved during the winter in silos. In the early spring they are removed, and a diagonal core taken from each one is analyzed. The beets are in this way separated into grades: those showing above a certain percentage of sugar forming the *élite* or first grade, those falling within another class the second grade, with a third class lower, while all those which fall below the standard fixed for the lowest grade are rejected. Little has been done in this country in the way of the production of beet-seed, but for three years the United States department of agriculture has grown the highest-grade seeds at its station at Schuyler, Nebraska, in accordance with the principles set forth above. The careful experiments undertaken by the department at this station at Schuyler have shown that beets quite equal to the best grown in Europe are easily produced in the United States.

The manufacture of beet-sugar also represents the foremost advancement in mechanical improvement; it is a science of itself; it requires special machinery and apparatus, and its practice is a benefit, not only to the persons immediately engaged in it, but, reflexively, to the whole community.

The sugar-beets, which mature in September or October, are carefully harvested, and the foliage, with a portion of the neck of the beets, removed by a knife. Each beet must be handled separately for this purpose. A portion of the top of the beet is removed because that portion contains a large percentage of the salts found in the beet.

SUGAR-BEETS IN CARS AND IN SILO—FACTORY-YARDS, NORFOLK, NEBRASKA.

These salts—chiefly potash—exert a very injurious effect upon the sugar-juices during the process of manufacture. They are bitter, they unite with any oil which the beet may contain and form soap, and they prevent large quantities of sugar from crystallizing.

The sugar-beet, having been brought to the factory prepared as above, is first passed through a long trough by means of a screw, through which water flows in the opposite direction from the movement of the beets. The beets are thus thoroughly cleaned, all fragments of soil and pebbles being detached therefrom. Thorough washing is highly important, since the presence of sand, or soil, or grit of any kind upon the beets when they reach the cutting-machine rapidly dulls the knives and produces bruised and imperfect cuttings. The beets, having been washed, are elevated to a cutter immediately over the diffusion battery. This cutter is a horizontal disk carrying several corrugated knives. These knives slice the beets, usually into V-shaped pieces, so that, when placed in a tank, water may freely circulate among them.

The beet cuttings, called "cosettes" or "schnitzel," are next conducted to the diffusion battery,—a piece of apparatus designed for the extraction of sugar by means of the osmosis of the sugar-juices with the water which is brought into contact with the beet cuttings. The diffusion battery consists of from twelve to fourteen cells so arranged that a liquor can be passed at will from one to the other and drawn off from any one of them at any time. The hot water which is used for the extraction of the sugar passes from one cell to another, becoming more and more charged with sugar-juices. When it has passed through a sufficient number of cells,—usually ten to fourteen according to the size of the battery,—it reaches finally the cell last filled with beet cuttings, and from this it is drawn off into a measuring-tank. When the battery is once filled, its operation is continuous, one cell being filled with cuttings and the exhausted cuttings being discharged from another every time a portion of juice is drawn into the measuring-tank. The exhausted pulp is passed through a press by means of which a large portion of the water is forced therefrom, and the residue makes a most excellent food for cattle. This ration, however, is not a well-balanced one, and certain nitrogenous and fatty bodies are mixed with it in order to make a perfect food. Oil-cakes are very suitable for mixing with exhausted pulp for this purpose.

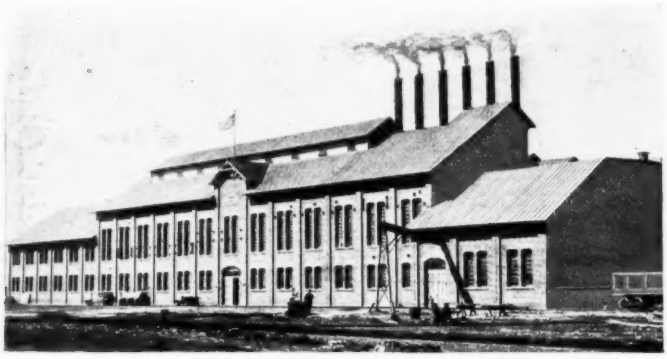
The sugar-juices, withdrawn from the battery as above mentioned, are passed into large tanks, where they are saturated with lime, from two to three pounds of which are used for each hundred pounds of juices. The temperature of the mixture is then raised gradually, and meanwhile a stream of carbonic acid is blown through the mixture.

FACTORY OF THE NORFOLK (NEB.) BEET-SUGAR CO., SHOWING FARMER'S APPROACH.

By this treatment the lime is precipitated as carbonate of lime, carrying down with it a large portion of the impurities originally contained in the beets. Beet juices, when first extracted, are usually of a dark, almost inky color. After treatment with lime and carbon dioxid in the manner above described, they are usually perfectly brilliant and of a beautiful amber tint. After the lime is all precipitated the juices are passed through filter-presses, on the cloths of which the lime and impurities are retained while the bright juices run through. A second treatment with lime and carbon dioxid is uniformly employed, and sometimes a third, in order to secure sugar-juices of high purity. The carbon dioxid used for this purpose is derived from a lime-kiln in connection with the factory, which also furnishes the lime necessary for the precipitation of the impurities.

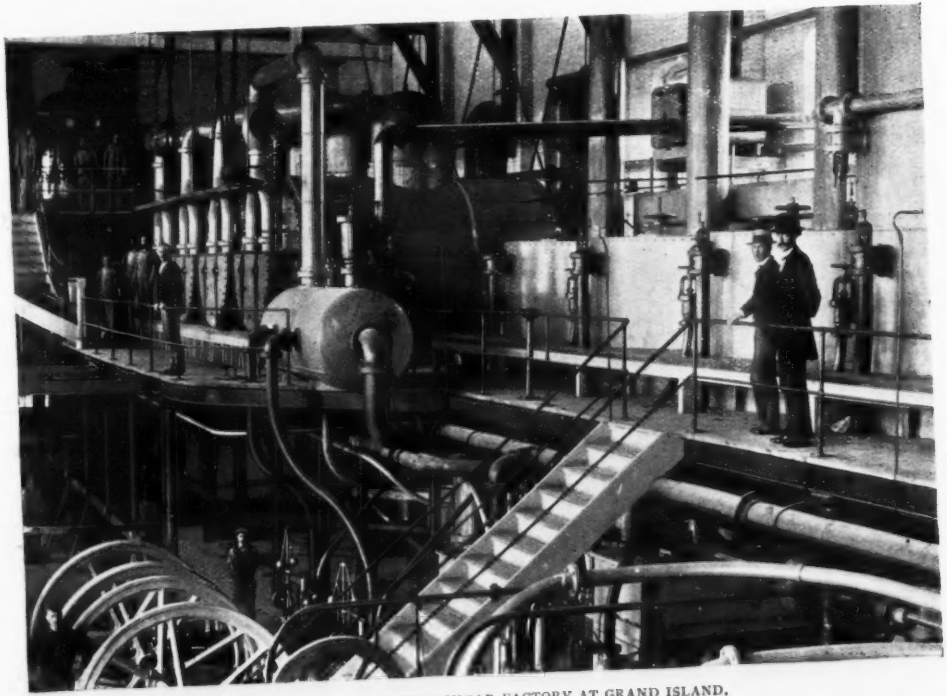
The purified juices, treated as above described, are next conducted to a multiple-effect evaporating apparatus. Here the juices are concentrated to syrup, the vapors from one of the multiple effects being used to boil the liquor in the second, and the vapor from the second being used to boil the liquor in the third. When this apparatus has two pans, it is called a double effect; when three, triple; they rarely contain more than four, while three is usually the number found.

The syrups, treated as above, if only raw sugar is to be made, are carried directly to the vacuum-strike pan. Small quantities of syrup are first taken into the pan and reduced to the crystallizing point. When fine crystals of sugar appear, additional portions of the syrup are drawn into the pan, continuously or from time to time, and the small microscopic crystals first formed begin to grow to the required size.



BEET-SUGAR FACTORY AT GRAND ISLAND, NEBRASKA.

[Capacity, 350 tons of beets per day.]



INTERIOR VIEW OF BEET-SUGAR FACTORY AT GRAND ISLAND.

[Quadruple Effects and Tanks for Saturating with Lime and Carbon-Dioxid.]

This operation usually requires from three to sixteen hours, according as the pan is a quick or slow-boiling one.

The sugar thus crystallized during the process of boiling is removed from the pan into a mixing apparatus, where it is thoroughly mixed by means of revolving arms. It passes then directly into the centrifugal apparatus, which, having perforated sides and revolving with great rapidity, quickly removes the molasses from the crystals, leaving the latter in a very dry form and suitable for transmission to the refinery.

In some beet-sugar factories the refining is done during the process of manufacture. In this case the syrups, before concentration, are filtered through bone-black or saturated with sulphurous acid. By these methods a pure white crystal of sugar is obtained, which, on being dried in a granulating apparatus after coming from the centrifugal, forms granulated sugar.

The molasses which is obtained by the above process is reboiled, and a second crop of crystals obtained therefrom. The molasses from this second crop of crystals is reboiled, placed in tanks, and left to stand for five, six, or even eight months, at the end of which time another crop of crystals, dark and mushy, has been formed, which can be separated by the centrifugals in the usual way. The final molasses, which contains a considerable quantity of sugar, is used either for distilling purposes, for fertilizing purposes, on account of the large amount of potash which it contains, or it may be subjected to treatment with freshly burnt and ground lime, at a low temperature, in which way the sugar which it contains is precipitated as sucrate of lime, from which the other impurities can be separated. The sucrate of lime can afterwards be beaten up with water into a paste and the lime precipitated with carbon dioxid as above described for purifying the juices. In this way almost all the sugar which was present in the molasses can be recovered.

The manufacture of sugar is a continuous process,—*i. e.*, the operations go on day and night. It is probably twenty-four or forty-eight hours from the time the beets enter the factory before the crystals of sugar secured therefrom appear, and the process is of such a nature that it cannot be broken except, usually at the end of a week or two weeks, when the house is shut down for repairs or renovation. An ordinary beet-sugar factory has a capacity for the consumption of about 250 tons of beets per day, and should make from 200 to 240 pounds of sugar per ton. In Europe larger factories are very common, capable of working from 400 to 600 tons of beets per day. In central factories there is a large number of diffusion batteries situated at different points, in which the juices are extracted. From these different places the juices are delivered to the central factory by means of pipe-lines, usually

laid under ground. A central factory of this kind will be found able to take care of the juices from 1000 tons of beets per day.

Every one who desires to see the prosperity of American machinery, American ingenuity, and American agriculture should favor the development of the beet-sugar industry. There is no other way in which the plethora of agricultural products can be so readily relieved and renewed prosperity brought to our agricultural interests, thus stimulating every other interest in the land. The total consumption of sugar in the civilized world is not far from 7,000,000 tons, of which the United States uses two-sevenths. Of the 7,000,000 tons over 4,000,000 are made from sugar-beets. It is thus seen that in the race for the markets of the world the sugar-beet is already ahead of its most dangerous rival, the tropical sugar-cane. There is room, however, for both these sugar-producing plants, and there is reason to believe that with favorable conditions a great indigenous sugar industry, including cane- and beet-sugar, can be established in the United States.

THE GROWING IMPORTANCE OF THE ENGINEER.

By J. F. Holloway,

Past-President of the Engineers' Club of New York City.

TO a close observer of current events, especially as they relate to progress in the industrial arts and in all that pertains to the convenience and comfort of the human race, it is perhaps quite unnecessary to say that engineering as a profession is steadily rising in the interest and the admiration of the world. Already the glowing light of a coming recognition of the usefulness of the engineer illuminates the hill-tops; already its cheering rays gild with glory the fame of those master minds who, in the past, did so much to make clearer the pathway and easier the road for those who were to follow in their footsteps. To-day the names of engineers who, in years gone by, labored and struggled amid discouragements and poverty that benefits might come to those who were to follow them, and who died in comparative obscurity, are now being enrolled high upon the temple of fame, where they are being brought into conspicuous notice by this increasing light of public appreciation.

As the world in its progress unfolds the future, and the labors and inventions of the engineer bring out of the crude material of nature new forces and forms of usefulness and beauty which shall, in the time to come as they have in the past, add to the happiness and comfort of all, the well-merited recognition of his aims and accomplishments will be heralded by that steadily-rising light until, ere it reaches its zenith, its rays shall crown in glowing splendor alike the highest and the humblest of the profession.

The great republic of France has for its president and chief ruler an engineer who has honored his profession by his wisdom, and who has so performed the manifold and difficult duties of his position as not only to have won the admiration of his countrymen and of the other republics of the world, but also to have received the homage due to his talents and manliness from the kings and emperors who surround him—who, from time immemorial, have held that the only road leading to such a position as he occupies was through an ancestry of royal blood.

Of late years there have grown into prominent existence national societies of engineers, who receive from the various cities to which

they are invited from time to time such attention and entertainment as have never been accorded to other professions and societies. In nearly every prominent city in America local engineering societies exist and prosper, strengthening and aiding their members by meetings and the discussions of topics of local and national importance, while, by occasional gatherings devoted to the amenities of social life, they compel a recognition that would not otherwise be accorded to them.

What American engineer is there whose bosom does not swell with commendable pride, and who does not go his way with head more uplifted and with footsteps more firmly planted, as he remembers the honors and attentions shown to his associates when, as "American engineers," a few years ago, they made a triumphal landing on the shores of the old world—a world which but recently reserved its plaudits, its pomp, and its ceremonies alone for the soldier or the sailor as he returned victorious from battle and conquest? That peace, no less than war in these later days, has its victories, was well exemplified by the marked attentions bestowed upon this body of quiet, unpretentious "American engineers." Bearing no other emblems of distinction than those belonging to gentlemen, no passports beyond that of membership in an engineering society of the United States, no emblazonry of rank beyond that conferred by an unpretentious professional button or badge, they were, from the moment they touched English soil until they left it to receive similar attentions in other lands, the recipients of honors and courtesies such as never before were bestowed upon any body of men, other than crowned heads or their immediate representatives.

Fresh in the remembrance of all is that great White City, so recently and so quickly built along the shores of one of our inland seas, and within the limits of a city now second only in wealth, population, and importance in America,—a city whose foundations have been built within the memory of men now living. Fresh is the glorious memory of that adjunct White City—marvelous in its conception and execution, impressive and grand in everything that tends to elevate and ennoble—and when, in the time soon to come, it shall be to us the "vanished city of the plain," when its cloud-capped towers and gorgeous palaces shall have faded away like a dream, may the remembrance of its loveliness linger long with us to remind us what we owe to the able architects, who, coming together, putting aside all petty jealousies and rivalry, united to show the world what inspiration and imagination could conjure up, and what patient study and plodding industry could accomplish. While we cheerfully accord our just meed of praise to the members of a profession so nearly allied to our own, we do not lower our regard when we concede that it was only through the labors of the engineer

and artisan, and by reason of what they had previously accomplished, that it was possible to present to the world the realization of what the architect and artist had so well dreamed of.

It would be invidious, if it were possible, to select the creation of one architect as being superior to that of another, or to describe in fitting terms the beauty that was symbolized in each of the magnificent buildings they produced. But I may say that, while from towering minarets and above massive domes pennants and banners proudly waved all the day long, first to catch the rosy tints of the sun as it emerged above the blue waves, and last to show its waning glory as it sank toward the horizon in the west, it pleased me most to note with swelling pride that it was upon the topmost pinnacle of the "Palace of Mechanic Arts" that the architect had made the angels to rest, and it was about the columns of the palace the engineer had filled with his creations that the wreaths of victory were entwined. Along the entablature they supported were written the names of engineers, many of them long since dead, but all of whom in their lifetime laid firmly the foundations upon which others since have builded so well. The massive engines beneath the roof, which had been gathered from many lands and which in their rhythmic beats turned the wondrous mechanisms there displayed, were but the refined exponents of the theories laid down by James Watt and others a hundred years ago.

No visitor to the fair who gave to the magnificent display of railway-engines in an adjoining exhibit any portion of the attention and thought they so well deserved, who considered their steady, upward growth and improvement from the first crudely-designed and roughly-built engines to the splendid specimens of these later days, who recalled what he had heard of the trial of the little "Rocket" at Rainhill long ago, and remembered the jibes and jeers with which the canny Scotsman was greeted when he announced his purpose to make a wagon go by steam, and who then thought of what has since been accomplished through the agency of the locomotive, would dissent from the proposition that among the names of the immortals the name of Stephenson should be written.

It was easy to see, in the improvements shown from year to year in locomotive-building, how there had been given to it the best thoughts and the increased experience of many men. As we look upon what they have now so well accomplished we are prone to forget the early toilers, many of whom lie in unknown and unhonored graves, though they, in the beginning, with no previous experience, with few or no tools to work with, marked out the course and blazed the way in which others, with better opportunities, accomplished what they could only dream of.

Grouped in that great White City was everything from alpha to omega of what the engineer had accomplished in the line of railway-appliances. But while millions of lookers-on passed up and down, gazing with curiosity, interest, or indifference, how few were there who read the story that these mute machines told. Here and there, amid the pressing throng, was some gray-haired man who, casting but a hurried glance at the new and highly-polished locomotives that stood so proudly at the head of the line, pushed down to find, perchance near the beginning, the little old engine which, as he remembered, came to the village wherein he was an idle schoolboy. As he stopped to look with loving eyes on each bar and bolt and wheel and curving pipe, the memory of the old days came back to him as he thought of the then new railroad with its strap-rails and quaint engine and cars, and he remembered that, had the choice then been given him of a kingdom and a throne or a locomotive all his own, the kingdom could have gone to another. Perchance in after years he had himself stood upon the foot-board or in other ways had known what it was to hold in his hand a lever that gave him control over untold forces to let them free or curb them at his will,—and what that feeling is only the chosen few know. But, be that as it may, as he turned away with averted eyes from the little old engine the passers may have wondered what the old man saw in that worn and rusty machine. Had they been wiser and known the memories it had evoked, they would have passed by with uncovered heads.

With the names of Watt and Stephenson, upon the high entablature, were written those of other engineers who in their lifetime had done much to help onward the progress of the age in which they lived, but time and space forbid their mention now. Suffice to say, about each life so spent there are for the pen of the ready writer facts and fancies enough to fill a volume which would read like a romance. If the mere mention of the engineers of the past and present implies so much, who can describe fully all that they have accomplished?

So strange, startling, and rapid have been the exploits of the engineer that the world has lost all sense of surprise, and has ceased to wonder what he will do next. To follow out any one of the numerous lines of work in which he has been engaged, to trace the development of the first crude mechanism he produced up to the splendid triumphs of the present day in almost any department of industry, would be no idle task. Long ago, as history tells us, all Europe was ablaze with the wild enthusiasm engendered by Peter the Hermit, as he summoned the Crusaders to the task of wresting the holy sepulcher from the hands of the infidel. Never before had the world witnessed such an uprising, never before had the pomp and circumstance of war

held such high regard in the minds of all. From every mountain-side, from out of the valleys and narrow defiles, the mail-clad warriors came swarming over the plains of Europe to meet together under the walls of the holy city. The story of the conflict there has been told in the legends and songs of all languages. There the Toledo blade of the cavalier flashed in the air to meet the descending scimitar of the turbaned Turk, until, amid the clash of arms, horsemen and horse alike struggled and died in the dire affray, and the streets ran red with blood. Centuries afterwards, when, save here and there, a cloven helmet or a pierced cuirass housed in an ancient museum was all that was left to tell the tale of the slaughtered hosts, the turbaned Turk was still to be seen calmly sitting in the city gate, filling its bazaars, and worshiping in its mosques.

But there arose another Crusader, with his face turned toward the orient and a deep-set purpose in his heart. No Peter with waving torch heralded his coming or lighted his way, no waving banners or blaring trumpets preceded him on his march with a few trusty followers. Armed only with compass, chain, and level, he landed on the eastern shore of the Mediterranean, where, peering through his instruments, he slowly marched over the plains to the foot-hills beyond. Still guided by his star in the east, he entered the narrow defiles through which the pilgrims and travelers had for ages trod. Creeping up along the mountain-side for many weary days and nights, he at last found the looked-for path that led him to his wished-for end. Coming back to the sea he shut himself up in his room, and, on the paper before him, he plotted out his route and planned his campaign. Later on, a band of pioneers armed with pick and shovel also landed, and, following the marks the leader had left behind him, they cut away the mountain-side, filled the valleys, and bridged the ravines and rivers.

Following them came another band of workers, strewing the new-made earthworks with a network of wood and iron that for all time to come was to bind in enduring bonds the lands on which they rested. Their work being done, there was landed on the shore of that eastern sea, and not far distant from the scene where long ago the Trojan horse had worked such wonders, another horse whose wonder-workings have far surpassed the one of Troy.

Planted on the roadway of steel, the iron-horse, after conquering all the western hemisphere, and after slaking his thirst in the waters of the Pacific, turned his front toward that eastern land whence came the human race, winding among the defiles and along the mountain-sides of Judea. Thus the Crusader of our day marched, undaunted and unchecked, until at last, rounding a high promontory and rushing across a bridge of steel, the streets of the holy city were reached, and Jerusa-

lem was won—won over to a progress and civilization that never turns back when once the engineer and his works have found entrance and an abiding-place.

While all who love their kind will be pleased to know that this victory of the nineteenth century was one of brains,—trained to the pursuit, not of war, but of industrial pursuits,—it must please us of this new world most to know that the engine first to climb the rugged heights of Judea, first to waken from their long, despondent silence the streets of this new Jerusalem with its rumble of swiftly-turning wheels and stirring breath, first to fling out into that cloudless sky its steam-white banner of peace and good will to man, was an American-built locomotive, handled by an American-born and -bred engineer. While over and above the engine and its train of cars the flags of many nations, new and old, floated in the breeze, it was the starry banner of the greatest republic the world has ever seen that waved to the fore.

The growing importance of the engineer and of his profession has already reached a point where it may well challenge the attention of the young men of the present who are anxiously looking into the future, in order that they may select a line of endeavor which shall insure not only material prosperity, but an honored place among those who have well served their day and generation. Noting what an extended space in the public prints is awarded to the exploits of the politician, and how lucrative in many ways are the emoluments that come to him, it is not strange that many are tempted to adopt politics as a "profession." Yet, if they stop to consider how uncertain is the source from which the power of the politician is derived, how suddenly political friends may change from enthusiasm to indifference or even open hostility; if they will remember how ephemeral is the fame accorded to the holder of a political office that sooner or later must go to another,—they must hesitate to follow after such a will-o'-the-wisp.

Empires, dynasties, and political parties, with their attendant courtiers and intriguing cabals, rise and fall, and the story of what they have done or left undone soon drifts into the musty records of the past, to be forgotten. But to the men who, by their ingenuity and indomitable will, wrest from nature her hidden secrets, harnessing them to the car of progress and helping humanity onward towards that higher civilization that shall make all the world better, and "all akin," is due, and in good time will be awarded, the honors they have so well earned. Foremost among that to-be-remembered class will be found the engineers of the past and their worthy successors of the present.

ELECTRICITY

Conducted by Franklin L. Pope.

IT is by no means easy for a novice,—nor, for that matter, for many presumably well-informed electricians,—to grasp at once all the ins and outs, so to speak, of the polyphase systems of electrical distribution. They have furnished, however, an attractive opportunity for the mathematical electrician to display his talents, and one which he has not been backward in improving. But now comes Mr. Charles P. Steinmetz, who is not only a mathematician of more than ordinary ability but a practical man as well, in the best sense of that word, who says that no two of the advanced mathematical theorists who have had so much to say on the subject agree, either with each other, or with the results of actual practice. Furthermore, he ventures to suggest that one reason for this state of facts may be, perhaps, that many of these writers have never seen, much less constructed, a polyphase motor. He severely criticises, from a practical point of view, the polyphase motors exhibited at the World's Fair, contending that, with one exception, they all manifested the same faults: excessive current upon starting (some being unable to start themselves at all when under load), high self-induction, great difference of phase, and so on, all of which, he contends, are faults which may be eliminated by proper means. He contends that it is possible to construct polyphase motors having all the advantages and few or none of the peculiar disadvantages of direct-current motors, and points out in detail wherein these consist. He contends that synchronous motors should be used in preference to induction motors whenever possible, as they not only are smaller but have a higher efficiency.

AT the recent annual convention of the National Electric Light Association in Washington, an attempt was made to collect trustworthy information as to the amount of coal used in actual practice, in the United States, to produce a given quantity of electricity. The data presented was procured by correspondence, the number of amperes, volts, and hours on each circuit reported being considered in connection with the actual amount of coal consumed during the same period of time, including that used for banking fires. In this way the actual number of watt-hours per pound of coal was arrived at in each case. The results, as might have been expected, varied widely, but the best of them cannot be said to compare very favorably with the results which have been reached in the generation of power for manufacturing purposes. The average of watt-hours per pound of coal was found to be 91.7. The most satisfactory result was that in a large station generating about 8,000,000 watts and running twenty-four hours per day, which gave 208 watt-hours per pound of hard screenings, while the opposite extreme was reached in the case of a station which claimed only 30 watt-hours per pound of soft coal, the output being 30,000 watts and the service seven hours per day. A comparison made between these results and those attained by the engines of a large manufacturing establishment in Brooklyn certainly furnishes food for thought. In the plant last named a load varying from 495 to 765 indicated horse-power, averaging 653.3 horse-power, was maintained with a coal-consumption of 1482 pounds per indicated horse-power per hour. The equipment consisted of Corliss compound-condensing engines and vertical tubular boilers, which were in operation ten hours per day. The fuel used was George's Creek bituminous coal. The efficiency of this plant, there-

fore, is nearly double that of the best electric plant reported, and about thirteen times that of the worst one.

IN a paper read before the National Electric Light Association, the question of the use of the earth as a return-circuit in the electric-railway service was discussed by J. H. Vail, who called attention to some very important facts. Instances have been known, he says, in which as much as 40 per cent. of the total return-current from an electric-railway circuit finds its way back to the central station through the water, gas, and other subterranean metallic-pipe systems. It has been established by careful tests that a current even of no more than five amperes may produce a very considerable electrolytic action upon a pipe in the course of a year, often resulting in material damage. The rapidity of action in any particular case depends upon the character of soil, the amount of moisture, and the quantity of current, but the destructive action in any case is constant and sure. Mr. Vail says that the track-system of all electric railways should be the positive side, or out-going circuit, in order that any arc which occurs between the trolley-wheel and the trolley-wire will carry metal from the wheel and deposit it in the wire. With the reverse arrangement, the strength and conductivity of the wire must ultimately become seriously impaired. The remedy which he proposes for existing difficulties is to bond the track-rails in a thorough manner, so that the conductivity of the joints will be nearly or quite equal to that of the standard rail-section, and to supply the track-system, thus bonded, with insulating feeders and extending directly from the station to predetermined points with an accurately calculated fall of potential. This, he points out, will result in reduced fuel-consumption, better working motors, great reduction in expense of repairs, and increased efficiency of the entire system.

PRESIDENT E. A. ARMSTRONG, in his address before the National Electric Light Association, said that, according to the most trustworthy information available, there were now in this country upwards of 2300 electric central stations, representing an invested capital of at least $200,000,000, and it was estimated that at least an equal amount was invested in the manufacture of electrical machinery and supplies. He had remarked a tendency, especially during the past few months, towards a revival of the agitation for the establishment of municipal electric-light plants, which he had reason to think had been instigated by representatives of some of the large electrical manufacturing corporations.

THE measurement of the illuminating power of arc-lamps by ordinary means, with any approximation to accuracy, has long been recognized as a practical impossibility. It is now proposed that a 2000 candle-power arc-lamp shall be understood to be one requiring an average consumption of energy of 450 watts, the measurement being made at the lamp terminals, and with no appreciable resistance in circuit with the arc. It is to be hoped that the definition will be accepted, and this much vexed question finally disposed of.

THE most serious difficulty which the electric central-station manager is compelled to contend with, looking at the matter from its commercial side, is the comparatively small number of hours in the year during which his invested capital is productive. Thus if each incandescent lamp in service is kept alight for a period of 1000 hours out of the possible 8766 hours in a year, it is considered to be doing very well. This necessitates what would at first appear to be an exceedingly high rate of charge for the power corresponding to a given amount of light. It has been for some time very apparent to central-station managers that some scheme must be devised, if possible, whereby the consumption of current may be increased during other parts of the day than at the time of the maximum load, viz., from dusk to 10 P. M. In such case a lower average rate could be charged for the illuminating service, and yet the general business and net receipts could at the same time be

materially increased. W. S. Hadaway, Jr., in the *Electrical Engineer* (New York), points out that the efficiency of the ordinary cooking-range, as determined by Tyndall, Beaumont, and others, does not exceed 4 per cent., indicating that of every twenty-seven pounds of coal consumed, in that appliance, twenty-six pounds are actually wasted, whereas the efficiency of a well designed electric central station of moderate size may fairly be taken to be about 6 per cent. Hence there would seem to be sufficient margin between a heat efficiency of 4 per cent. and one of 6 per cent. to warrant the use of electricity as a source of heat in culinary operations. Even at the same cost, there are many advantages gained which appeal strongly to the average housekeeper. The saving of time and attendance, the avoidance of heat in the kitchen, and the capacity for accurate control and regulation, to say nothing of absolute emancipation from the nuisance of coal and ashes, are all considerations of no small practical importance. There appears no good reason why the well-to-do classes of the community, who can afford to use electricity for lighting, cannot equally well afford to use it for cooking and laundry-work. The employment of electricity for these branches of domestic work alone, if it should become general, will go a long way toward solving one of the most perplexing problems which puzzles the central-station manager.

A SPECIAL report has been made to the mayor of Brooklyn by the subway commissioners, in reference to the matter of the corrosion of pipes by electrolysis due to stray currents from the conductors of the electric street-railway systems. By way of illustration of the nature and extent of the damage arising from this cause, the report is accompanied by photographs of specimens of pipes and telephone cables which have been removed from different localities in that city. The same trouble has made its appearance in many other cities, notably Boston and Cambridge. Various remedies are suggested, some of which have been tried, while others are only proposed, but it is perhaps true that an effectual cure, other than the radical one of compelling the street-railway companies to completely insulate their conductors from the earth, is yet to be discovered. It is apparent, however, that the effects of electrolysis may be in many cases materially diminished by the employment of certain precautions. The direction of the flow of current in the railway circuits often makes a great difference, as experiment has amply demonstrated. It has been found that the corrosion may go on actively when the difference of potential is less than half a volt. The conclusion of the commissioners is that a very considerable amount of injury is being done to underground wires and cables, and that it is likely to continue until some better method of returning the electric currents to the generator than that now in vogue can be devised and put in practice. But they say that "it is doubtful if the method of final cure for the difficulty has yet passed its experimental stage."

THE question as to whether it is possible to employ a storage-battery with advantage in connection with a direct-current central station is one which Professor Elihu Thomson says is not susceptible of a general answer. Each case must be considered on its own merits, and with careful reference to all the conditions involved. For traction work, he points out that the experience has thus far not resulted favorably to the claims of the storage-battery, from the standpoint either of economy or of technical adaptability, and that this has been true, even where the conditions in respect to grades and other circumstances have been most favorable.

PROFESSOR SHEPARDSON, of the University of Minnesota, communicates to the *Electrical World* (New York) the result of some important investigations made by two of his students in relation to the actual loss of light which takes place from the use of the ordinary arc-lamp globes. Several curves of intensity of light under different conditions are given, which are of much interest. It was found that a

mean spherical illumination of 319 candle-power from the bare arc is reduced to 235, 160, and 140, respectively, when clear, ground, and opal glass globes were used, a maximum of some 55 per cent.

ACCORDING to Edward Weston, the loss in energy which occurs in the switch-boards of some of the large electric stations is amazing. He states that he had occasion recently to examine a switchboard carrying a current of 8000 amperes, in which the waste due to badly-fitted joints in the board, and faulty arrangement of the station ammeters, figured up nearly $5000 a year. He mentions a single ammeter which was found to require $89 worth of energy per year to run it.

THERE seems to be a marked tendency to the development of the arc-lamp in the direction of its application to incandescent circuits. Although many varieties of arc-lamps have been designed for this purpose, which give more or less satisfactory results, most of them are practically of the same type, the difference being mainly one of detail in construction. One great difficulty hitherto has been in the waste of energy due to the necessary introduction of dead resistance, which, under some conditions, may amount to nearly 50 per cent. On the other hand, the actual experience of a company which supplies current for a very large number of arc-lamps, both on the series and low-tension systems, shows that current can be produced for the low-tension lamps at a figure 25 per cent. less than for the high-tension series lamps. The actual result appears to be that, on a large scale, there need be practically but little difference, so far as actual cost of operation is concerned, between the two systems.

FEW persons who are not experts appear to have any conception of the enormous losses which sometimes occur in badly-designed and ill-proportioned systems of electrical distribution from central stations. Actual measurements which have been made within the past year on electric-railway plants operating with a station pressure of from 500 to 550 volts, which showed a pressure of not more than 300 to 325 volts at some of the remoter parts of the system, indicating a direct waste of power between the dynamo and the motors of over 40 per cent. of the coal consumed. Such a result indicates the existence of fundamental mistakes in the original planning of the system. Similar errors, though usually less glaring ones, are not uncommon in electric-lighting systems, but in these the effect upon the illumination is usually so patent that there is a much better chance of their being sought out and remedied than in the case of a railway system in which the losses are comparatively unseen.

THE electrician of the Chicago Association of Fire Underwriters has recently submitted a report on the causes of fires, from which it appears that, of the seventy-seven fires alleged to have been caused by electricity, there is scarcely a single instance in which the trouble might not have been avoided, either by the use of better material or by the exercise of greater care and discretion in the wiring and fitting. Some of the cases reported, as, for example, that of the attachment of a call-bell to a 50-volt circuit within a building, can only be characterized as instances of inexcusable, if not criminal, negligence.

A RECENT census of the electric-light and -power industries of France shows that (exclusive of Paris) there are now 301 central stations, aggregating 38,200 horse-power, of which 21,820 is steam, 9259 water, and 6000 steam and water combined, the remaining power being furnished by gas. Water-power is used in the greater number of stations, there being 136 of these as against 113 operated by steam. The relative proportion of alternating- and direct-current stations is in curious contrast to the conditions prevailing in this country, there being no less than 248 of the former to 47 of the latter. Many of the more important stations now under construction in France will employ the polyphase system of distribution, and will use gas-engines for motive-power.

THE adoption of municipal ordinances regulating the maximum speed of electric street-cars has developed the necessity of applying to each car some automatic device which shall notify the employés and the traveling public whenever the prescribed limit is being exceeded. A recent contrivance for this purpose consists of a centrifugal device attached to one of the car-axles, which, by means of a connection which is adjustable to suit any required speed, is made to sound a bell at each revolution of the axle until the speed has been reduced to its proper rate.

THE solicitude which for some time has prevailed in certain quarters in reference to the application of electricity to the propulsion of boats on the Erie canal turns out, as might have been expected, to be of a not wholly disinterested character. A corporation with which a number of prominent citizens are associated has been granted a permit for fifty years, authorizing it to enter upon all the canal lands of the state for the purpose of erecting and maintaining a plant for the distribution of electricity for heat, light, and power in the cities and towns along the line of the canals, in consideration of which the company is to furnish the state with electric power for operating the lock-gates, and for the illumination of the locks at night. Electric power is to be furnished to private boat-owners, at a rate of charge not exceeding $20 per horse-power during the season of navigation. The state reserves the right to purchase the canal towage or traction plant at any time hereafter, at an advance to 10 per cent. upon its original cost. The corporation to which these privileges have been granted appears to be one of the subsidiary organizations of the Niagara Power Company, and it is of course the intention to obtain electrical power from Niagara Falls, and to dispose of it in the numerous thriving cities and towns along the line of the canal between Buffalo and Albany. The enormous value of a clear right of way for the distributing conductors, such as that afforded by the route of the canal, is apparent. The maximum of charge to the boat-owners cannot be said to be at all unreasonable, though it is undoubtedly enough to afford a satisfactory margin of profit to the supply-company. It is comparatively a matter of small consequence to the company whether the boatmen avail themselves of the opportunity to use electric power or not; the main thing is the securing of the right of way for supplying electricity to the cities of central New York. It is not unlikely, however, that the use of electricity on the canal may become sufficiently general to demonstrate the advisability of enlarging its capacity to enable it to more nearly meet the demands of modern commerce.

ONE of the fundamental errors made in the electric-lighting business at the outset was that of charging the consumers at a contract price per lamp per year, although, from the lack of a suitable meter, this was at the time to a large extent unavoidable. One company undertook to furnish its customers with a lamp in place of every gas-jet removed, basing the rate of charge upon the gas-bills of the preceding year, and afterwards found, upon applying meters to the service, that it had been getting paid for only 32 per cent. of the gross output. Another case reported is that of a hotel which was being supplied at a flat rate of $175 per month, which, when metered and charged for at the regular rate, amounted to no less than $1100. Some companies which have adopted the meter system have been able to cut down their output one-half and at the same time increase their revenue. There is nothing bought or sold which does not represent energy, and there is no equitable way of buying or selling energy except by weight and measure.

IT is a fact, which has long been patent to those well versed in the history of electric telegraphy, that the essential features of the system now in almost universal use throughout the world embody little or nothing of the original inventions of Professor Morse, although the American system of telegraphy always has been, and probably always will be, inseparably associated with his name. In its essential

principles, and even in its structural features, the telegraph, in its modern form, is in essence nothing more than the electro-magnetic signalling apparatus of Joseph Henry, constructed and exhibited by him at the Albany Academy in 1831, to which has been applied the mode of operation and conventional alphabetical code devised by Alfred Vail in 1837. The contribution of Morse to the ultimate result has not inaptly been likened to the false work of an arch, which has not only given its form and organization to the structure, but without which its very existence would have been impossible, and yet which forms no necessary or even desirable part of the complete whole. A series of papers now in course of publication by Miss Henry in the *Electrical Engineer* gives a circumstantial and interesting account of the mental and physical processes by which her honored father was led, step by step, to one of the most important—if not the most important, when measured by the vastness of its effects—discoveries of the nineteenth century: that of the fundamental principle underlying the construction of the electro-magnet, and its relations to the source of electricity from whence its energy is derived. Much of the matter given by Miss Henry is from original documents, and now appears in print for the first time. It seems eminently fitting that this work should be given to the world by the favorite daughter, who not only shared in, but as her writings show, thoroughly understood and appreciated, the labors of the most eminent of American philosophers.

DURING the past summer the West End Railway Co. of Boston made quite an extensive experiment in the way of electrically welding the rails of its tracks, of which some mention was made in these notes at the time. It now appears that about 10 per cent. of these welded rails have broken in service. The experiment seems at least to have established the fact that the alignment of the rails, either vertically or laterally, is not affected by the expansion and contraction,—a contingency respecting which some apprehension had been felt,—but it is yet to be determined whether the contraction has been the real cause of the breakage referred to. It is understood that the experiments are to be continued, but that, hereafter, the entire abutting surfaces of the rails are to be united, and unusual care is to be taken not to injure the fiber of the metal or to restrain the expansion due to the heat. It certainly is to be hoped that the method may prove practically successful, as the continuous rail very perceptibly increases the smooth running of the cars and must materially lengthen the duration of the rolling-stock used on the line.

THE suggestion has been made by Professor Elihu Thomson that the temporary stars which have occasionally been observed to blaze out with great brilliancy and afterwards to fade away may be explained on an electrical hypothesis,—that charged bodies possessing a difference of potential, upon approaching each other, might exchange electricity upon a grand scale, making a display which would continue but for a short time.

IN spite of the outcry made by the newspapers about the dangers accompanying the use of the "deadly trolley," statistics show that the number of casualties is by no means excessive in proportion to the work done. The West End railroad, running in the crowded and crooked thoroughfares of Boston, reported last year only one person killed or injured to every 56,575 miles run. If it were possible to restrain the poorer classes of the community from permitting their small children to make a play-ground of the public streets, the fatalities, few as they are, would be notably diminished. One of the most fruitful causes of accidents is due to the practice of such children of catching surreptitious rides upon the rear steps of cars and suddenly jumping off, when confronted by the conductor, just in time to fall under the wheels of a car going in the opposite direction, a species of accident which no possible caution on the part of the motorman is of any avail to prevent.

ARCHITECTURE

Conducted by Barr Ferree.

THE architectural education of the American architect is one of the most serious and important of professional questions. In no other country are building operations, by builder and by architect, conducted on so large a scale as in the United States, and in no other country, it is but simple truth to tell, have the architects so rapidly come to control such vast and important enterprises. The great buildings of America exceed in size and in cost the great buildings erected by modern European architects. The American structures may be less important in function, and less monumental in aspect, but the money considerations involved are often much larger than is the case in modern European structures, save in occasional instances. Further, the position of the American architect, as regards himself, his profession, and the public, has changed very much in the last few years. It is true that we have not yet reached a point at which incompetent architects are no longer able to make a living in their profession, but that is simply because the greater part of the building population is not yet able to realize what a competent architect is. That is something for the profession as a body to teach the public. Meanwhile, their importance to the public is constantly increasing, and it is becoming of more and more vital importance that the architect should be possessed of the knowledge and skill necessary to perform his manifold duties. The architect's education is, therefore, one of the burning professional questions of the day. Some aspects of this question have been treated already in these pages, but there is begun in this number of the Magazine a symposium on "Architectural Education for Americans," the importance of which we do not think we exaggerate when we describe it as the most important contribution yet made on this topic. Never before have the advocates of the chief systems of architectural education met in converse with each other; and while the papers are independent, not argumentative, each presenting the merits or demerits of the particular system the writer represents, their union, in the brief series here begun, gives them a fresh and important interest they could not have were they scattered among separate publications. Mr. Rotch, who presents the claim of the École des Beaux-Arts, has studied at the famous school and won a name for himself as one of its most distinguished advocates. Mr. Andrews, who argues for a more utilitarian and practical system of architectural education than has yet been put into practice in this country, was trained solely in an architect's office, and his words are, therefore, the weightier on that account. Mr. Robert W. Gibson, who, in the succeeding number of the Magazine, will take up the English system, is one of the most brilliant graduates in this country of a system we know too little about. The series will be concluded by a brief paper by the present writer, presenting "An Outsider's View."

AN article in *The Century Magazine* for March, on the Madison Square Garden, might appropriately have been styled "The Apotheosis of Faddism." Never, surely, has the faddic critic risen to greater heights. Yet what more can be expected of a writer who speaks of the "dearest architectural possessions" of New Yorkers? It would be most interesting to know where these possessions are kept; clearly not in New York itself, for, if all the great metropolis were to be swept off into its encircling waters, what loss would there be to art, what hindrance to progress, what would be ruined that could ill be spared?

The most reasonable argument against the advantages of such a catastrophe would be that, in the event of its occurring, the most conspicuously bad architect in the city would succeed in reaching the loftiest piece of débris and would be saved, to begin again the construction of monstrosities that too frequently in the past have been considered, within New York's most cultured circle, types of very high architecture. Of course the Madison Square Garden cannot be described in such rough language, yet we do not hesitate to say that the article referred to will speedily be ranked among the curiosities of architectural criticism, if, indeed, so sonorous a title should be applied to an article which seems to be a cross between an advertisement for the architects,—for quite a list of their "jobs" are printed in it, with hints at others,—or for the Garden itself as a place for amusement. One experiences something of a shock in coming across a sentence like this in a sober architectural discussion: "There can hardly be a better place for a big circus than this." Yet with all the faddist's enthusiasm for her subject (and why will the authoress continually refer to herself as "him"?) the writer is unable to close her eyes to certain very obvious faults in the subject supposed to be under review while others she passes over on the plea of ignorance. Why then, if incompetent, write on the subject at all? The article is divided into five sections, or chapters, only two of which are directly concerned with setting forth the faddic conception of beauty and art in the building. We are sorry we have not room to reproduce the paragraph on "a partner whose name the public seldom speaks." It is quite the funniest thing in architectural literature we have seen for many a day. It may be ladylike; it is certainly not gentlemanly.

READERS of certain public organs, affiliated with a certain famous political party, have long been familiar with the remark that "put the————party into power, and you may be certain it will discredit itself." Whether this is true as regards politics we should not like to affirm, but very much the same thing can be said of the editors of the so-called "big" magazines, when they undertake to publish an architectural article and seek to adorn it with pictures. The article itself may be right enough, but the cloven hoof is always visible in the illustrations. Look, for example, if you please, at the picture of the center of the Madison-avenue façade of the Madison Square Garden, in *The Century* for March. That particular centerpiece always seemed to us somewhat pitched on without relation the rest of the building, but it certainly is too bad to print an article whose chief and only end is the exaltation of that building among the works of mankind, and then deface it with such a caricature as this. But if *The Century* is bad, *Scribner's* is worse. It was in this magazine, it will be remembered, that the editor of a comic weekly announced to an awe-stricken world that the arch of the main doorway of the Transportation building at the World's Columbian Exposition was Roman,—an archæological discovery, by the way, that has never received the attention it has deserved, though we have tried to do our part in making it known. Well; almost anything might be looked for in a periodical that would print such talk as that but some of the pictures that accompany the article on "The High Building and Its Art" in its March number are among the most extraordinary that have appeared anywhere. There is a very fine and realistic snow-scene in Boston, with what purports to be the Ames building in the background, and looking so cold and ugly and forbidding that the eye naturally travels to the snow-covered State House in the foreground. This is well matched by a view of the stairs leading to Brooklyn bridge at the City Hall Park, New York, though the picture is not so labelled. The Schiller Theater, which the unfortunate author who was the occasion of these phantasies being given to the world (though not the cause) speaks of as "one of the most beautiful and impressive high buildings in the world," is shown in a view that makes his words a mockery. Nor is this all. The chief point of the article is the insistence on the vertical as the leading

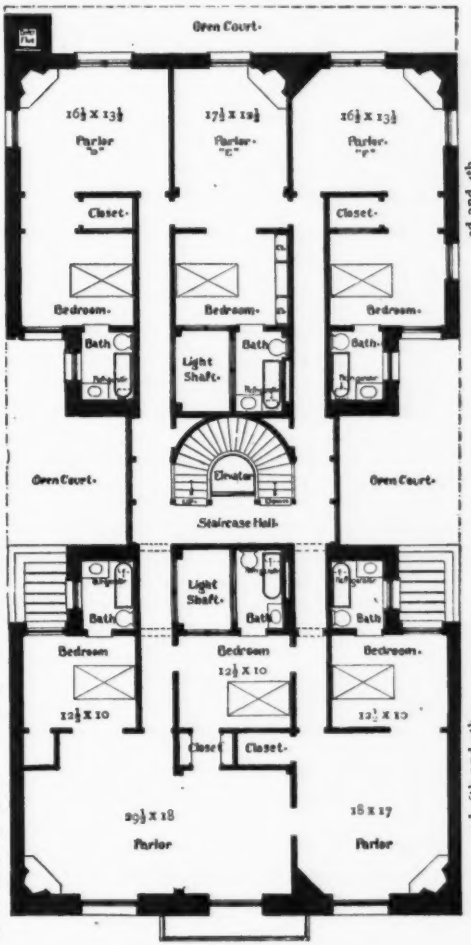
element in vertical design. Yet in three illustrations that should bring out this point—the Union Trust building (St. Louis), the Mills building (San Francisco), and the Havemeyer building (New York)—the vertical lines are omitted or repressed, and only the horizontal lines inserted! As the old schoolmaster recently remarked, in the aforesaid comic paper with the editor of an archæological turn of mind, *Umpery trumpery dixum digit sockdologus.*

DID you ever see a building afflicted with the smallpox? If not, it is well worth a journey to Union square, New York, to see such an amazing spectacle. It is not to be supposed that the obtaining of such an effect was the intention of the architect, since the owners of the building have issued numerous circulars calling attention to the attractive quarters that may be found there (for a consideration). And of course it is not criticism to begin the description of a building by making so offensive a comparison, yet this is exactly the effect the author of the Decker building has obtained by the use of bricks, supposedly ornamental in pattern, that are disposed in a symmetrical manner upon the façade; and having obtained this result, why not say so? The lot is only thirty feet wide, and an eleven-story building has been erected upon it. This height is in itself more than ample for a building on a lot of this size, a fact which must be obvious to every one save the maker of the design, who has stretched it out at the top by means of an absurd tower that is rendered more absurd by the hipped roof pinned on on either side of it. The upper part of the building, unfortunately the most conspicuous portion, is utterly barren in artistic treatment, and succeeds only in telling how little the man who made it knew what he was about. This is not unimportant in itself, but it is a pity the information had to be given in so permanent and visible a form. It is, perhaps, scarcely fair to begin with the top of a building, though where it is so wonderful as in this instance any starting-point might be forgiven. Of the base itself nothing need be said. It is a simple store-opening supporting a huge window in a highly-ornamented frame, that stretches across the whole front and needlessly accentuates the opening at the base of the design. The superstructure, if the main portion of the building immediately over this may be so called, is plain enough in its first form, but a simple front did not seem to meet the requirements. Four balconies, arranged in the form of a Maltese cross, have quite needlessly been put up on the front, to the most unfair disadvantage of the tenants not provided with these adjuncts. Two-story windows are introduced into the middle of the design without any connection with each other or the rest of it, affording a most charming diversity where, of all places, it was least needed, and yet having a sort of mellow feeling that prepares one for the festive elements with which the building is finished. It is not the least of the misfortunes of this building that it is the very much the highest structure in the block in which it stands. The raising of the other buildings will not improve it, though it will lessen its aggressiveness. Fortunately the cable cars go pretty fast here.

PROFESSOR A. D. F. HAMLIN, the accomplished adjunct professor of architecture in Columbia College, announces a four months' tour in Italy for students, for a serious and systematic study of the Italian Renaissance. While there is not the slightest necessity for transferring the work of the Italian Renaissance to this country, such a course of study as is proposed by Professor Hamlin will unquestionably be of the utmost advantage to those who avail themselves of the rare opportunity this tour offers. Professor Hamlin is not only an accomplished teacher of architecture, but a profound and brilliant scholar, and those who place themselves under his guidance will have the satisfaction of traveling and studying under the leadership of a most accomplished cicerone, with the added pleasure of a sympathetic master, amply versed in the subject he is teaching. Many architectural tours have been proposed, from time to time, but we know of none that

promises better results, or is based on a more excellent idea, than that Professor Hamlin has put forth. The study of any style in the class-room is a very different thing from its study in the monuments themselves, and when to this obvious advantage is added the instruction of a master the opportunity becomes one of a lifetime. The class will meet in Naples early in June and follow a carefully-prepared itinerary, though we understand this may be modified with the consent of the majority of the students. It is an altogether new feature in architectural education in this country, and it needs no prophetic vision to foretell most striking and notable results therefrom. Preliminary "public talks" on the route and monuments to be studied will shortly begin in New York, so that the utmost amount of preliminary work may be done before the journey is begun. Those who are able to take advantage of this plan may well be envied for the extraordinary advantages they will enjoy, and we trust that Professor Hamlin will secure a large and appreciative class. He can hardly escape an enthusiastic one if he can communicate a tithe of his own enthusiasm to his men. We recommend that architectural students—and this should not include very young men alone—who are contemplating a European jaunt this summer place themselves in immediate communication with Professor Hamlin, who may be addressed at Columbia College, New York, and all who approach him may, we are sure, confidently count on a hearty and generous response.

MESSRS. CARRERE & HASTINGS have produced a very clever plan for their *Life* building in New York. This is an eight-story structure intended for bachelor apartments and studios, the lower floors being devoted to business. Clever as the plan is, it is simply a modification and adaptation of a plan already much in use in New York and elsewhere for tenements and dwellings. The floor-space is divided, by two courts opened into the center of each side, into a front and back building. These open courts light the rear rooms of both front and back buildings, on which are placed the sleeping- and bath-rooms belonging to the corner suites of apartments, as well as the middle of the building block, in which are placed the stairway and elevator. As an additional court is placed on the rear of the building, it follows that



PLAN OF THIRD FLOOR, "LIFE" BUILDING, NEW YORK.

the parlors, bedrooms, and bath-rooms are all amply lighted. Two small light wells are introduced into the center of the building which light the bedrooms and bath-rooms of the middle suites of rooms, both front and rear, as well as the adjacent corridor. Throughout the building the utmost pains have been taken to secure the maximum of light and air at the cost of a minimum of floor-space. The typical floor-plan shows great simplicity of arrangement and wise use of space, and the whole gives evidence of most careful and judicious study.

PHILADELPHIA is one of the most delightful cities in the world to visit. It is especially so in times of mental depression and worry, for the good town itself is so depressed by nature, and is so calm and peaceful withal, that one positively relishes meeting with an atmosphere below one's own, while enjoying the vacuity of space that cannot be had in busier towns. Philadelphia architecture is also, as all the world knows, a sight worth many a day's journey to see, and it is altogether possible to enjoy a brief sojourn in what is one of the most singular and striking of American municipalities. Yet, strange as Philadelphia architecture is, it is most strange that there has recently grown up, among the sordid and preposterous structures for which that city has long been famous, a really notable school of architects who are producing some of the most artistic and satisfying architecture within the geographical and political limits of the United States of America. In other words, the unexpected and unforeseen has happened, and an architectural Renaissance, of extended proportions, of interesting variety and of very charming results, has made its appearance in Philadelphia. Long may its beneficent influence be felt, and may its shadow never grow less!

The most notable work produced by the Philadelphia school of architects,—for their importance is such that they may justly be so styled,—has been done by Messrs. Frank Miles Day & Brother, Wilson Eyre, and Cope & Stewardson Some others are following in the paths these pioneers of the artistic in Philadelphia have opened up, for, though the good influence of these four men has been slow, it has been steady and will grow and increase from year to year. The prevailing note in their work is its fine artistic feeling. It is not always great,—indeed, it would be unjust to speak of them as great architects in the fullest sense of the word,—but it is good, and seeks generally to obtain its results by form and proportion rather than by ornament and elaboration. That such a school should rise up in Philadelphia is the most healthy sign of the decay of barbarism in this country we have met with in many a day. Mr. Day's ornament is sometimes too small in scale for the building on which it is placed; Mr. Eyre does not always escape from an affectation of form and of grouping; and Messrs. Cope & Stewardson sometimes err a little in both directions; but the work of each is very good in itself,—quite the best that is done in Philadelphia and decidedly better, as a whole, than much of the work done in more enlightened communities. It is work that is not only pleasing and satisfying in itself, but that repays careful study, and has formed the basis of other work by other men in Philadelphia and elsewhere. We repeat: the work of this quartette of Philadelphia architects is entitled to rank among the best done in this country, and we congratulate Philadelphia in being able to afford a sufficiently-remunerative practice to keep men of such marked ability at home. Each day brings increased appreciation of the value of their work, and each day is hastening the time when the architecture of Philadelphia will cease to be a reproach to intelligent men. The progress of the architectural Renaissance in Philadelphia has been most interesting and satisfactory, and its future history promises, under such accomplished leadership, to be among the most brilliant revivals of the art we have had in this country.

RAILWAYS

Conducted by Thomas L. Greene.

THE *Financial Chronicle* publishes statements for the calendar year 1893 of the gross and net earnings of 198 railways, having an aggregate length of 117,000 miles. The statement therefore comprises about two-thirds of our railway mileage. The railways last year did a fairly good business for about five months. During the summer and fall the freight traffic fell off very heavily, the decreases being offset to a great extent by the largely-increased passenger receipts owing to the World's Fair. The result of the combination of these good and bad elements shows but a trifling change over 1892; the gross earnings exhibiting a decrease of 1.6 per cent., the operating expenses 0.9 per cent., and the net earnings a falling-off of 3.4 per cent. These percentages do not set forth the present situation fairly, the latter months of 1893 and the opening months of the new year making a much worse showing than the other months. The railways whose fiscal year ends on June 30 will not have so favorable an exhibit to make. Meanwhile, however, it is pleasant to know that the results of the calendar year are, comparatively, so good.

There is now no doubt that but for the World's Fair travel the railways would have shown very different results for 1893. This can clearly be seen from the annual reports already made public. The Chicago and Alton, for example, reports a continuous decline in freight traffic since 1887, the year in which so many railways in its territory extended their lines; a policy which that company did not follow. As to the passenger traffic, however, while the number of local passengers was slightly less than in 1892, the number of through passengers increased nearly one-third, so that the total number of passengers carried one mile was greater by 20 per cent. than in 1892, while the number of train-miles was a trifle less. As a consequence, the average earnings per passenger train-mile increased from $1.21 to $1.46 in 1893, a gain which is to be ascribed almost wholly to the Chicago travel. The passenger gains from the World's Fair were large enough on the Chicago and Alton to offset the losses in freight traffic, so that the company was able to report net earnings of the same amount as in the previous year. What is here said in detail of the Chicago and Alton is true of all the railways centering in Chicago.

THE report of the Pennsylvania railroad, one of the greatest systems in the United States, has been widely published. The figures dealt with are too large to admit of close analysis. The point of most interest in the report is that the income of the railroad from outside investments is larger than the interest on the funded debt, a showing which no other company is able to make. The Pennsylvania, from year to year, bought the stocks and bonds of roads which could profitably be joined to its system and swell its traffic. It rarely happens that these auxiliary lines show a profit from their own working; their benefit to the parent railway is usually indirect. A year or more ago, when the then Reading managers were attacking the Pennsylvania, it was alleged in pamphlets circulated both here and abroad that this outside income of the Pennsylvania was not accurately stated, and that some of the subordinate companies did not really earn the money credited to them in the Pennsylvania report. Detailed information is not available for proving or disproving this statement made in controversy. There seems no reason to doubt, however, that the legitimate income of the Pennsylvania railroad from self-sustaining parts of its system is enough to contribute materially to the dividends paid. It is also to be noted as an element of strength that the

Pennsylvania railroad spends from its earnings upwards of $2,000,000 each year in betterments not charged to capital account.

IN contrast to the strong position of the Pennsylvania railroad must be noted a number of other companies in the United State, whose requirements for bond interest each year are so close to their earnings that in a period of depression the safety of the companies is impaired, while every possible expense, whether necessary or not, is cut down. The *Railroad Gazette* has compiled a table giving the amounts owed, first for expenses and then for all prior charges before dividends, out of each $100 of gross and net earnings for eleven representative companies:

	Of gross earnings.	Of net earnings.
Boston & Albany	$80.05	$16.17
Chicago & Northwestern	85.39	57.27
Chicago, Burlington & Quincy	85.45	59.30
Chicago, Milwaukee & St. Paul	86.70	61.00
New York Central & Hud. Riv.	89.86	67.97
Louisville & Nashville	88.74	70.10
Atchison, Topeka & Santa Fé	95.36	85.83
Union Pacific	95.20	87.46
New York, Lake Erie & West'n	96.98	91.32
Philadelphia & Reading	96.31	91.45
Northern Pacific	103.72	107.97

The five last-named companies are now in the hands of receivers, their margin of safety having been exhausted. We touch here upon the besetting sin of American corporation finance. Railway-owners in the past have capitalized their expectations, so that, when legitimate expenses increase or traffic falls off, a receivership is inevitable. No railway company should willingly be bonded or stocked to such amounts as would bring disaster in dull times. If railway financiering were more conservative and healthful there would be a margin, even in periods of depression, which could be spent for the needed repairs and supplies.

THE year 1893 was the first since the civil war when the increase of railway mileage was comparatively less than the increase in population. This simple statement is at once an evidence of our business depression, and also a good ground for hope that the stagnation in the building and maintenance of railways is temporary. It is significant of the possibilities of the future to know that while Massachusetts has 26 miles of railway for every 100 square miles of territory, Pennsylvania 20, and Ohio 26, the younger states of Nebraska and Minnesota have but 7, Kansas 11, North Dakota and California 3, and Georgia 8, while the Mississippi-valley states occupy an intermediate position between these extremes. As immigration fills up the population of our newer states we may reasonably anticipate that the number of miles of railway in those states will in time approximate to the proportion in the more thickly-settled eastern states—that is, will be increased one-half, as population increases to warrant the additional construction.

THE contract given to the Hall Signal Co. for the putting in of their system of block signals on the Delaware, Lackawanna, and Western railroad has given rise to some discussion regarding the relative merits of various kinds of apparatus. It is not possible or necessary in these columns to enter into a long examination of the whole question, but a word or two may be said in reference to the particular case at issue. The New York Central is a good type of the railroads which have an excellent block-signal system operated by hand. That company has guarded against the possibility of mistakes on the part of operators as much as possible by using the Sykes interlocking apparatus, which requires the consent of two operators before trains are admitted to the block. There are certain advantages in such a system which all must admit. The objection on the part of the railroad-men is not to the original cost of the apparatus, nor to its reliability, but to the addition which it requires to the operating expenses of the road. The tower-men must be paid, say $40 per month on the average, and, although in the country the blocks can be made long, it can easily be seen that the increase in the

annual expense is an important item. The reason for the success of the automatic methods is because these do away with the employment of so many men: thus the Pennsylvania railroad out of New York city is using an automatic signal, moved by compressed air and controlled by electricity, put in by the Union Switch and Signal Co. Iron bridges are put across the track above the trains, on which are semaphores indicating by position whether the block is free. The power necessary to move these arms, particularly during storms of wind or sleet, requires an apparatus of some strength and cost. Moreover, such an automatic system needs constant and careful inspection. This inspection is almost as expensive as the wages of tower-men would be, especially as the system is yet in its infancy, so that the annual cost of operating the system has not yet been reduced low enough to satisfy the majority of the railways.

THE principle of the Hall system is practically the same as that in use on the Pennsylvania railroad, with the exception that, instead of moving the signals by pneumatic power, the Hall company rely exclusively on electricity, the current being conveyed through the track. The objections which heretofore have been urged against systems operated through track current, the Hall company believe, have been removed in their case by the use of the best materials and workmanship; but electric power is not strong enough to operate the comparatively heavy signal-arms used on the Pennslyvania railroad. If electricity, therefore, is to be used as automatic power, some lighter form for the signal proper must be devised. The Hall company meet this difficulty by using boxes with a round face at the top, like an old-fashioned clock, covered with glass; inside this box a disk is displayed which can be seen through the glass easily by an observer at a moderate distance. Not a few railroad-men think that a system of signals to be really useful should be of such a character as to be seen by the engine-driver from a long interval, and which could not become obscured, say by a storm of sleet. To those who hold firmly to this opinion the Hall system of signals may seem objectionable. On the other hand, other railroad-men say that a signal which can be seen within 200 or 300 yards is all that is really required, and is all that the best signals can offer in a fog or a storm,—the very time when they are needed the most. Such men make no objection to the Hall system of displaying signals through a glass box, except as to the possible obscuring of the signal by adhering snow or sleet. The advantage of the system of operating signals by electricity alone is, or ought to be, the comparative cheapness of the apparatus, for the cost ought to be much less than any system using compressed air. Railroad companies which prefer to use an automatic system of block-signals must take their choice between the more expensive apparatus which uses signals easily seen from a distance, and the cheaper form which is subject to the limitations already mentioned.

THE important question of the duties of railroad employés to the public has received renewed attention under the orders issued at Milwaukee and Omaha forbidding employés on the Northern and Union Pacific railways to strike. The receivers of these roads reduced the wages of their men and then obtained an order from the court prohibiting the employés or their trade-unions from conspiring or agreeing together to quit the service. These orders have stirred up a great deal of indignation among the laboring classes and their friends both in and out of congress, and the actions of Judges Jenkins and Dundy have been severely criticised. If we consider the strike matter separate from the question of wages, it is well to say that all good corporation lawyers are agreed in thinking the principle of these court orders to be correct. When railways are operated by the court, of course the court is directly responsible for the continuance of the service to the public. The fact of the receivership brings this truth directly to the attention of the judge. Whether wages are too high or too low is a question which ought to be settled in some other

way than by a stoppage of trains. When brakemen or switchmen accept service on a railway they take their positions under an implied agreement to respect the rights of the traveling and shipping public. Of course these employés are free men and have a legal right to leave the service of the company whenever they choose, but it is more than doubtful whether they have a right to combine with their fellow-employés so that all should quit their positions at once and leave the railway unable to run its trains.

It is very likely true that the orders of these judges were too broad, and covered, by implication at least, more than was really intended. It is also a grave question whether it was just for these courts to declare a reduction of wages on the recommendation of the receivers, without hearing evidence to the contrary from the employés themselves. Indeed, the courts of the several districts through which the Union Pacific runs have already fallen foul of each other on this very point. The whole controversy, however, may turn out to be of great importance as pointing out the way toward a settlement of the perplexing labor problem. On the one hand it is quite possible that the precedent of the Ann Arbor case, followed by these later cases, will result in the adoption of a definite policy by the courts to the effect that strikes ordered through combinations of laboring men are illegal, if they have for their object the stoppage of trains, whose continued movement the judges are coming to believe it is their public duty to enforce. On the other hand, the same trade-unions have a right to go before the same courts and oppose a reduction in wages or advocate an advance. Thus the question of the proper scale of wages may receive some judicial interpretation.

PROFESSOR RICHARD T. ELY, of the University of Wisconsin, is an entertaining writer whose articles appear from time to time in our popular magazines. Professor Ely is a pronounced socialist in the sense that he believes it would be better if nearly all of our large industries were in the hands of the state. His critics assert that his theories are not well reasoned out, and that he neglects to consider some important and even elementary facts bearing upon his position. His favorite idea, to which he returns again and again, seems to be that the railways of the country ought to be owned and managed by the government; but in this scheme of nationalization Professor Ely omits to discuss the question of ways and means. It is true that the credit of the government is good, and that it could borrow money for the purchase of our railways at 3 per cent., but the debt which it would incur in such an enterprise would be as great as that caused by the civil war. If railway employés now strike against reductions of pay or for increases, it may be set down as certain that their demands for large salaries and wages would be most pressing if the government were their employer. In fact, an increase in all expenses would be inevitable. Meanwhile the farmers, whose wheat is not bringing cost at the farm, and all other producers the value of whose products depends to an important extent upon the cost of transportation, would clamor for lower railway charges, and in the end would be certain to get what they want. If many of our important railways are now close to the margin of safety it does not require a prophetic mind to see what the result of the workings of these two opposing forces would be under government ownership. The revenues would decrease and the expenses would advance until they met or even crossed each other, and before long not a dollar would be earned on the enormous government debt put out to purchase the transportation lines. The annual interest would have to be paid, and would be raised by general taxation. Every American reader of this Magazine would have to pay his share of these taxes, whether he used the railway or not. The present system, with all its faults, is more equitable, at least in this one respect, that those who travel or ship goods pay for the privilege, and cannot ask the non-traveling or non-shipping public to bear their burden for them.

MINING AND METALLURGY

Conducted by Albert Williams, Jr.

AS showing not only the pressure of hard times upon iron-ore mining, as in all other industries, but also the remarkably close shaving now necessary and which presumably still admits of a profit a contract just announced is noteworthy, It is for 90,000 tons of Bessemer ore from the Norrie mines on the Gogebic range, to be delivered at $2.75 per ton at South Chicago. This ore, after standing the expense of mining and royalty, has to be carried by rail about forty miles to Ashland, the shipping-point, thence by lake to destination, with additional costs for insurance, commissions, and incidentals. The rate is said, by the *Engineering and Mining Journal*, which gives an analysis of the items, to be nearly a dollar lower than was thought possible last season. The actual cost of bringing the ore to the surface (that is, for all mining costs) is stated on good authority to be not less than 65 cents a ton, a figure which evidently cannot be much cut down. Taking former freight-rates, etc., as basis, only 20 cents a ton would be left to cover interest on mining capital and all other charges, which, as the *Journal* says, is "entirely too narrow for comfort." Evidently some very close figuring all around has been done.

ONE consideration is frequently overlooked in figuring what a mine can stand in the way of low prices for its product, and that is that the mine is not inexhaustible. A mine is not like a farm, which, under prudent management and with proper fertilizing, can go on indefinitely yielding its crops year after year; nor yet like a factory, which with due allowance for repairs and depreciation of plant, has only to meet one year's demands at a time. Every ton taken out of the ground is an absolute diminution of resources by just that one ton. There were so many tons there originally, no matter how vast the deposit; and there is no way of replenishing the stock started with. Now the money invested is to be repaid by that which comes out of the mine, and this output must not only pay interest on the investment, and that too at a pretty high rate, to allow for the mining risk, but it must also act as a sinking-fund; so that, when all the ore is finally exhausted, as sooner or later it inevitably must be, the sinking-fund shall have extinguished the original outlay. The life of a mine, however long, is a finite quantity; and, under modern conditions of pushing the capacity to the utmost, the time is steadily lessening. Yet mine-operators seem to overlook this vital factor in their enterprises and go on basing their calculations upon a never-ceasing output. It is not a case of killing the goose that lays the golden eggs, yet there is something somewhat similar in such a policy. Of course this line of reasoning is in a sense theoretical merely, and it must be admitted that managers who have to meet the stress of sharp competition must do the best they can and submit to sacrifices if they would keep their mines going at all. But it is none the less a point worthy of serious thought. And yet was there ever a mining report (barring the preliminary surveys, with their "ore in sight" estimates) that, in presenting a balance-sheet, made any allowance for diminution of resources?

IN some kinds of mining it is possible to estimate in advance about how long the deposit will last, at a given rate of extraction. This is true of regular and well-surveyed coal-beds, for example. It is true also, in less degree, of placer mines, where the area and depth of the deposit are known. It does not hold with most metalliferous mines, whose ore-bodies are irregular and more or less pockety. When a coal-mining enterprise is set on foot it is customary to figure out so much available coal per acre, and so much acreage to be mined in a given time; yet, after mining is

actually begun, the preliminary calculation (on which the investment was based) is lost sight of entirely. If such is the case where the best opportunity exists for prudent prevision, how much the more careless in those cases where the exact extent of the deposits cannot be foreknown.

DIVERSE views as to the operation of the patent system of ownership of mining claims have been brought out in a discussion between some western papers. One or two have claimed that the system is working injury to the interests of the country insomuch as some of the owners of prospects that have been patented refuse to work them themselves and will not sell except at rates that are practically prohibitive. That is, that there are those who hold mining ground on speculation, hoping to make a big deal by selling to some eastern or foreign syndicate. The *Mining and Scientific Press* (San Francisco) puts in a word in behalf of such owners, and says:

> There are no doubt many cases where actual benefit would result if an owner did not have quite so secure a hold upon his idle property. But every man has a right to do what he will with his own. . . If it is not possible to obtain absolute title to mining ground, the industry would be destroyed, or, at best, it would be terribly crippled.

It has been the aim of the law-makers in the United States and the Spanish-American countries to accomplish two results,—to encourage the active development of the mineral resources and at the same time to secure owners in their holdings. To gain these two things laws have been framed whose provisions are in a measure antagonistic. First, to compel the claims to be worked, there is the assessment-work plan (temporarily suspended in the United States), which requires the owner to do a certain amount of work each year upon his claim, the penalty being forfeiture of title and liability to having the claim "jumped" by any one who considers it worth taking up—and, in the early rough-and-tumble days, who was strong enough to hold possession. Then there is the patent system, intended to firmly secure title to owners who have gone through certain forms of locating, having official surveys made by government deputy surveyors, advertising intention, paying certain fees and doing certain work; after which, a patent having been issued through the land office, the theory is that the title is safe in perpetuity. There is no question as to the good intent of both systems, nor that they are skilfully elaborated with the view to working side by side with as little friction as possible. It happens that there are unavoidable weak points in both cases. Assessment work has always been more or less a farce, and it has been a source of uncertainty, either at the time or subsequently, to determine whether the required work has or has not been actually performed. This has led to interminable legal wrangles, to say nothing of personal collisions. On the other hand, the patent system of ownership does not afford perfect security, any more than does the patent on an invention, both being open to later adjudication whenever there is enough value to contend for. If the whole of our intricate mining laws could be wiped out, and a simpler system substituted which, without being retroactive, would for the future bring the ownership of mineral ground to the same plane as that of ordinary real estate, it would be a great improvement. Then, as now, but more strongly, could be endorsed the saying of the *Mining Press* that "every man has a right to do what he will with his own," it being understood that no direct injury is done, though a negative loss might be claimed as affecting the general prosperity of the commonwealth—which is a nice question. However, the great trouble at present is not that there are unnecessarily idle mines, but that it is so difficult to really secure ownership.

A PRELIMINARY statement of the production of copper in the United States in 1893, by Mr. Charles Kirchhoff, Jr., gives the total domestic output at 329,692,461 pounds. In the year 1893 there were 7,623,387 pounds of copper produced from imported ores and pyrites. Imports of metal in pigs, bars, ingots, and "old," were 5,536,696 pounds. Exports were smaller—113,984,128 pounds of metal. The fine copper

contents of matte exported were estimated at 50,000,000 pounds. Reëxports of foreign ore and ingot copper were 2,019,821 pounds. The total available supply at the close of the year was 176,948,589 pounds, a notable decrease from the stocks on hand at the close of the preceding year.

A NEWSPAPER devoted to the mining interests, speaking of the recent disaster at the Gaylor colliery at Plymouth, Pa., betrays a queer notion of what "pillars" in coal-mines are. It naïvely explains to its readers, in order that they may have a clear understanding of the situation at the time of the accident, that "in mining coal in the vein"—as though there were any other place to mine it than in the vein [bed]—"massive pillars of coal are left standing to support the roof, forming *a natural colonnade*," and so on. This architectural concept of the appearance of the workings of a coal-mine is ingenious and a stroke of imagination on the part of the editor who evolved it from his inner consciousness, but hardly serves as a basis for lecturing the miners.

THE basic process of steel-making, which has been steadily gaining ground in Europe, is greatly helped by the use made of its by-product, phosphoric slag, now largely used in agriculture. This process, also known as the Thomas, treats ores containing a notable percentage of phosphorus, which until the introduction of the process, had always been the great bugbear of steel metallurgy. Indeed, within limits, there is a great demand for phosphorus in the ore that actually makes what would formerly have been considered unmarketable ores much sought after, this demand for phosphorus being partly due to the requirements of the process itself, but latterly still more so for the sake of the slag by-product, which sells according to the percentage units of phosphorus contained, just as do our South Carolina and Florida natural phosphates. It is stated in a French technical journal (the *Côte Libre*) that the phosphoric slag realizes almost as much as the pig itself from which the phosphorus has been removed. In this way the basic has an advantage over the Bessemer process, the slag or scoria from which is of no value for the purpose. Bessemer slag has, however, been used in a small way for making brick and cement, by being granulated by pouring while molten into water, the granulated material then being dried and mixed with lime.

FLOATING in the "reprint" columns of the press is found the following uncredited paragraph, evidently an excerpt from some longer article or essay:

> The volatility of metals furnishes an interesting subject for modern science. Its study in a practical or commercial sense cannot fail eventually in the development of processes directly affecting the metallurgical world, both in methods and character of products. Elements hitherto refractory have by recent experiments been removed or changed. Iron, copper, gold, silver, tin, platinum, aluminum, and manganese are all included as capable of distillation. Silicon and carbon submit to the same process, and refractory alkaline earths are said to be on the same list. The chemist in metallurgy is becoming one of its most potent factors.

Notwithstanding the sophomoric tone, and the author's apparent ignorance that in the metallurgy of quicksilver, zinc, arsenic, etc., volatility has from time immemorial been the central feature of extraction processes, there is a kernel of sound truth in the foregoing sentences. Now that the electric furnace, with its high power, controlability, and considerable capacity, is available at reasonable cost, and while the sun-furnace remains a possibility, there is certainly opened a wide field for new lines of experimentation, with a very fair chance of some startling practical results that might revolutionize certain branches of metallurgy. Yet it must be admitted that, in treating the more valuable metals and their ores, the metallurgist would very gladly spare from them this quality of volatility, which is not only a nuisance, but also a direct source of loss. However, seeing that the quality is there and cannot be suppressed, the next best thing will be to seek to make the

most use of it, with the advantages of the high temperatures now attainable.

IT is stated that the Semet-Solvay process of coke-making, employed in France, and the Otto process, in favor in Germany, give per ton of coke burned 5½ kilograms of sulphate of ammonia, which is worth, according to the condition of the market, from 250 to 300 francs per ton. American coke-makers who are fully alive to all progress in the direction of improving the quality of their product, and whose works are models in the way of mechanical economies carried out by working on a very large scale, have not yet fairly turned their attention to the question of by-products. Of course there is a great deal besides this in the old controversy between the beehive and the "patent" types.

THE Comstock lode, Nevada, has presented some of the most difficult problems in mining, but it has also been the scene of some wonderful achievements, among them many involving the introduction of entirely novel expedients. Nobody ever claimed for it a reputation for economy, but it certainly has furnished examples of daring engineering and also of very rapid work, considering the disadvantages. A recent discussion of rapid shaft-sinking has led the Virginia City *Enterprise* to furnish the records here quoted. The Savage, Norcross, and Chollar joint shaft, known as the Combination, has four full-sized compartments, each six feet in length by four feet in width, requiring an excavation nearly forty feet in length by seven in width to allow room for timbering. This shaft was sunk to a depth of more than 2500 feet, and closely timbered with 12 × 14-inch timbers, in two years, and several working stations were opened at the same time, each capacious enough for a dance-hall. The joint Best & Belcher and Gould & Curry shaft, known as the Osbiston, was sunk to a depth of 2000 feet below the surface in 18 months. This shaft has three compartments. Both of the above shafts were sunk through a diorite formation, requiring heavy blasting for almost every foot attained in depth. A record of 110 feet a month has frequently been made by Comstock mining companies in sinking. For rapid drifting the Comstock has never been excelled. On the 3100-foot level of the Combination shaft a south drift was advanced 115 feet in one week, and this with a cloud of steam arising from the water in the sump, showing a temperature of 120 degrees; meanwhile the ponderous hydraulic pumps were lifting to the Sutro tunnel level nearly 4,000,000 gallons of this steaming water every 24 hours. The speed of driving the Chollar drift is said to have been excelled in several instances, but that in the Chollar is the longest drift ever run on the Comstock at that depth.

THE output of gold in the United States in 1893 is estimated by the treasury department at $37,000,000, an increase of $4,000,000 over that for 1892. This gain is the natural result of the greater attention paid to gold-mining since the silver-mining became, with few exceptions, unprofitable. About one-half of the increase is attributed to Colorado, where the Cripple Creek gold-mining district has begun a considerable production, which promises to be increased in the future. It is expected that the current year will show a further advance in the total gold production, to which the partial revival of hydraulic mining in California will contribute, while in general all the sources of gold in the country will be stimulated into greater activity.

A DEVICE for not merely eliminating but also utilizing the smoke of soft coal has been tried in the mint at Birmingham, England, and, it is said, successfully. According to the account it certainly surpressed the smoke, but there must be an added expense in its application, with some disadvantages as to draft. The apparatus is comparatively simple, consisting of a large water-chamber in which a horizontal agitator works at 280 revolutions per minute. Outside this tank, and connected with it, is a high-speed fan, running at 3000 revolutions and also connected with a tall chimney at its lower part. The fan intercepts the smoke, forcing it through

the condensing-tank, where the carbonaceous matter, sulphurous acid, and metallic fumes are caught in the water. A circulation of the water is made between the tank and a trough, and both are drawn off when sufficiently charged. The residue of the products of combustion, not condensed, passes from the chamber, entering the chimney at a point about forty feet up and thence escaping from the top as a thin, white vapor. The fine carbon collected is sold for electrical purposes and the sulphates in the liquor converted into a disinfectant. In the case of a mint or other metallurgical works we suppose the idea is also to effect a saving in precious metal. So far as the elimination of smoke is concerned, it is generally admitted that the best plan is prevention, not cure; that is, to secure a perfect combustion in the furnaces. For condensing metallic fumes this device may or may not act as efficiently as the ordinary water-spray. But at the best appointed metallurgical works reliance is placed upon long series of dry flues and dust-chambers connecting with very tall stacks, and having the combined draft of the blowers which feed the smelting-furnaces, auxiliary fans, and, finally, the natural draft of a high stack. At the Omaha and Grant Smelting Works, at Denver, the whole system of flues and dust-chambers is over a mile long, connecting with a main stack 350 feet high, the tallest in the United States.

THE bureau of anthracite statistics of Pennsylvania reports the anthracite shipments in 1893 at 43,089,585 tons, a gain of 1,894,320 tons over the shipments of 1892. The annual trade statement prepared by Mr. William H. Riley, showing that the consumption of anthracite in 1893 was larger than ever before, says that this was one of the anomalies of the year, occurring in the face of a general falling off in mineral production. In round numbers, the consumption of anthracite in 1890 was 36,300,000 tons; in 1891 it rose to 40,200,000 tons; in 1892 it again advanced, to 42,000,000 tons, increasing another million tons last year. The Wyoming region is now the leading producer, while the Schuylkill has fallen behind and the Lehigh region has increased slightly.

IN mines yielding sulphid ores, especially of copper- and iron-pyrites, the mine-water often becomes very destructive to the iron pumps and pump-columns. As the mines are opened and the ore becomes exposed to the air, oxidation takes place, forming soluble sulphates and, in certain reactions, free sulphuric acid. The corrosive effect of a copper sulphate in the water is probably due to the exchange of iron for copper in the precipitation of the latter by the former, though miners commonly ascribe it to simple free acid. The superintendent of the Gagnon mine at Butte, Montana, reports that there is considerable water constantly leaching down through the old stopes, and in so doing it seems to become impregnated more or less with sulphuric acid, which acts on the columns and pumps. He adds: "There is quite a difference in the character of the water in the different parts of the mine. The silver-mines do not have water that is particularly troublesome, but in the copper-mines there is a great deal of trouble. . . . Some 2½ years ago we put in a 7-inch column to throw this water to the surface, and for awhile it showed no particular corrosive action, but during the last spring a corrosive action on the iron was very apparent, and the surprising thing about it is that the action showed first at the top of the column. As it went on more leaks occurred, until one length of pipe of 15 feet had thirteen clamps on it. It was fully determined that we must use something besides iron, but just what ought to be used is a serious question. There is one copper column in the mines in Butte, but copper is so expensive that it is almost out of the question for us to think of duplicating that column. There is also one brass column 5 inches in diameter, but I understand there is some objection to that. I think it is probable that we will have to come down to using iron pipes lined with wood, which is the cheapest method I know of for keeping the water away from the iron."

Tarring the iron of the pumps and

columns, or the application of asphalt varnish, gives some protection. Wooden pipes (either bored logs or boxes) have been used in such cases where the pressure was not too great. One superintendent in Colorado seriously proposed to put in a rubber column for a 500-foot lift, but was laughed out of it. For small pressures and volumes rubber hose might answer. But in deep mines, having heavy floors of water to contend with, it is a serious problem what to use in place of exposed iron in pipes and other underground appliances, where the water is corrosive. Makers of underground machinery sometimes substitute bronze or brass in part for iron and steel.

MANGANESE steel containing varying proportions of manganese shows remarkable differences in behavior in tests, even when the percentage change is but slight. Not only this, but the results are not always what might be predicted in advance of experiment, and are often very puzzling. Mr. R. A. Hadfield, the distinguished Sheffield metallurgist who has for many years made a special study of this interesting series of alloys, in a paper on "Iron Alloys with Reference to Manganese Steel," gives the results of his experience in the manufacture of cast manganese steel. He has been led to believe that a special explanation of its qualities of toughness and resistance to fracture is needed. It has been commonly imagined that what is known as toughened material is secured in the casting without additional treatment. This is not so. Although the metal, even in its cast state, is sometimes remarkably tenacious and ductile notwithstanding its hardness, a further treatment, such as water-quenching, gives the best results. Mr. Hadfield is inclined to think that the variation noticed in its properties is somewhat dependent on the casting temperature and other similar causes, some of which are not yet fully understood. In all cases there is a great difference between the strength of 10 or 12 per cent. as compared with that of 5 per cent. manganese steel. The former is improved by water-toughening; the latter is not, and is of little use. It is at about 14 per cent. that the maximum of strength is obtained. Beyond that point there is a decrease, but the true cause is made complex by the higher percentage of carbon which goes with higher manganese. Mr. Hadfield believes that if the carbon could be reduced there would be considerable strength in alloys of 25, or even 30, per cent. manganese, and that such products would be forgeable. The entire paper should be consulted by all who are interested in recent advances in this important branch of metallurgy.

THE mine which is at present the greatest silver-mine in the world is the Broken Hill Proprietary, of New South Wales. Besides silver, it yields also gold, considerable lead, and some copper. For the six months ending November 30, 1893, it exceeded all its previous records by turning out 6,533,232 ounces of silver, 1431 ounces of gold, 25,822 tons of lead, and 333 tons of copper (in matte). This was from 260,047 tons of ore treated.

THE Johannesburg *Star* quotes the report of the chamber of mines of that place for 1893, which gives the total output of gold in the Randt district of the Transvaal at 1,479,114 ounces for the year. This is by far the best record yet. In 1890 the production was 494,810 ounces; in 1891 it was 729,233 ounces; in 1892 it had increased to 1,210,865 ounces. This steady progressive gain is one of the most encouraging features of the great gold-mining region of South Africa.

AGAIN a story comes of a wonderfully rich gold find having been made in the Colorado desert, with the comment that the miners think the discovery is where the Indians used to obtain the gold they showed to people in Caliente. This region is the favorite source of myth and romance —also of frequent disappointment and disaster. There really should be something there, on the principle that where there is much smoke there must be some fire; and there certainly have been enough reports to point to some basis for them.

CIVIL ENGINEERING

Conducted by John C. Trautwine, Jr.

IF William of Normandy could revisit the country he conquered some eight centuries ago, he doubtless would find much to astonish him, but perhaps nothing would come home to him with greater force than the sight of the great stone towers of the new Tower bridge, with their feet planted in the bed of the Thames and their heads reaching far above that of the famous "White Tower" of London built by the Conquerer himself, and still standing hard-by.

He would no doubt inspect the great structure under the guidance of Mr. John Wolfe Barry, the engineer-in-chief, who so courteously took the visiting American engineers over the foundation-works in 1889, and he would then note at least one essential difference between these modern towers and his own construction. Whereas the latter was just what it professed to be, a great jail and fortress, the former are, to a great extent, a sham and a pretense,—very real, indeed, and built of no sham materials, but sham in that they do not uphold the working parts of the structure, but merely hide from view the steel skeletons which actually perform this service. They thus not merely put themselves forward as doing a work which they do not do, but, like some of their human prototypes, conceal from view the real benefactors whose reward of praise they fraudulently reap for themselves. The grim fortress which was begun by the Conqueror about 1078, and which is still practically as good as new, if not better, stands close by the north or left bank of the river, a half-mile below London bridge; and the approach to the new bridge, to which it gives its name, climbs close along the south wall of the old Tower.

UNTIL the building of the present structure the world-renowned London bridge was the most seaward of the bridges over the Thames, and from that point downward the only means provided for crossing the river were the Thames tunnel, built by Brunel in 1825–43, the "subway" (for foot passengers only), and the ferries. But for many years the inconvenience of being obliged to use London bridge has been a very serious one to the enormous traffic crossing the river at this east end of London, for this meant not merely a serious detour to reach the bridge; the bridge itself is so narrow as to offer but a very insufficient highway for the stream of vehicular traffic crossing it. The roadway of London bridge is only 35 feet wide; yet the daily travel over it in 1892 amounted to over 22,000 vehicles and 110,000 pedestrians. The extent of the traffic demanding a crossing lower down stream may be inferred from the fact that below London bridge lies all that very important portion of work-a-day London which derives its business from the river, including the world-renowned docks, of which nothing in this country gives one the least conception. And yet so important is the shipping interest in the Pool, as that portion of the river lying just below London bridge is called, that the idea of submitting to a further throttling of the narrow stream by the building of a permanent bridge lower down could not be entertained.

After many plans had been submitted and duly considered, and after any amount of scheming and counter-scheming, both in and out of Parliament, the present remarkable design was adopted.

THIS design involves a channel-opening of 200 feet, with two bascule leaves, and a permanent overhead footway served by elevators running in the piers. The shore spans (one on each side of the river) are 270 feet each, and are upheld by suspension "chains" stretched between the great towers already referred to, and

shorter ones near the shores, while the overhead footway, with 141 feet headway above Trinity High Water, joins the tops of the principal towers.

The so-called main "chains," which support the two 270-feet shore spans, and which depend from the high main towers of the channel span at one end and rest upon the lower abutment towers at the other, are in fact formidable riveted structures. Each "chain" is in two halves, pivoted together where they meet at their lowest points near the roadway, and pivoted at their ends to the backstays or "land-ties" and to the high-level tie over the opening span, respectively. Each main chain has an upper and a lower chord, in the form of a box-girder, and the diagonal bracing which connects these two chords is also box-like in cross-section, while the land-ties and the ties over the opening span are composed of plates, riveted together, and are provided with pin connections at their ends.

The trusses for the high-level footways are of riveted lattice construction. There are two of these elevated foot ways, one on each side of the bridge, and served, as already intimated, by elevators running in the towers; but, as one never takes an English elevator (or "lift") except when there is plenty of time to spare, stairways are also provided for such pedestrians as may be in a hurry.

The two bascule leaves weigh very nearly 1200 tons each, and each is composed of four main girders on a steel shaft 21 inches in diameter. Each girder is a riveted braced half-arch. The bascules are counterpoised by weights of lead and of iron, and are worked by two hydraulic engines of 360 horse-power each, located on shore and operating two accumulators in each pier. The main piers of the Tower bridge are oblong in plan, and each consists, essentially, of four octagonal steel riveted steel columns, about six feet in diameter and 120 feet high, with parallel sides and braced, at intervals of about three feet, by horizontal plate diaphragms, with openings for the passage of the elevators. The four columns of each pier are braced together by three landings, which are connected by diagonal bracing in the plane of the sides of the piers.

EACH of the two main stone piers is 70 feet wide and 185 feet 4 inches long, and the bases of the foundations are about 93 feet below the main roadway, or 60 feet below Trinity High Water. Each pier foundation was constructed within a coffer-dam composed of twelve plate-iron caissons, which were sunk 15 feet into the London clay in the bed of the river. The caissons were about 2 feet 6 inches apart, but, after two adjoining caissons had been sunk, the space between them was cut off from the river by means of square piles driven at the ends of the space between the two caissons and the two adjoining sides of the caissons were then removed. The twelve caissons thus formed, when driven a continuous double coffer-dam around the site of the pier.

The imperviousness of the London clay rendered it practicable to excavate it to a depth of five feet below the foot of the coffer-dam and to the same distance beyond its walls. A bed of concrete about twenty-seven feet thick was then deposited filling the excavation thus made and extending up to the level of the river-bed. Upon this was started the outer shell of masonry of the pier. When this was completed, the upper or temporary portion of the coffer-dam was removed, and the masonry shell then formed the coffer-dam for the work of filling, which went on inside. The lower portions of the coffer-dams, nineteen feet deep, remain permanently in the work.

THE Tower bridge will bring a pressure of about four tons per square foot upon the London clay of the river bed. It was estimated that the settlement, under this load, would be about 3 inches, but observation shows that it will be somewhat less than this. A trial cylinder, loaded to the same extent, showed 1⅜ inches settlement after three days. At the Charing Cross bridge, which crosses the river a mile or two higher up, six tons per square foot were required to produce a settlement of three inches, while eight tons per square

foot, which is the pressure on the foundations when the bridge is loaded with locomotives, produced a settlement of four inches.

THE corner-stone of this great work, involving, as it does, the construction of the largest river piers in the world, with the exception, perhaps, of those of the Brooklyn bridge, and an application of the bascule principle upon a scale hitherto unprecedented, was laid by the Prince of Wales on June 21, 1886. The work is now practically completed.

It will be noticed that only pedestrian traffic is here provided for at all times. Vehicles must await the closing of the draw. In fact, the difficulties of the situation were such as to call forth a large number of original and radically-different schemes for effecting this crossing with a minimum of interruption to the two conflicting interests involved. Among these was the design of Sir G. Barclay Bruce, afterward president of the Institution of Civil Engineers. This contemplated a rolling platform, 300 feet long, which was to slide upon rollers placed upon the tops of six piers spaced 100 feet apart, so that the platform should, in any position, rest upon not less than two of the piers. Of three designs submitted by Sir Joseph Bazalgette, who was president of the Institution in 1884, one at least involved a spiral ascent with 150 feet radius on the south or Surrey side of the river. A design by Messrs. Knipple and Morris employed, instead of the overhead footway of the present design, a tunnel under the channel span. The ends of this tunnel communicated with the roadways on the shore spans by means of vertical shafts provided with lifts. These lifts were designed to carry not only pedestrians, but vehicles as well, and the design thus had this great advantage over the one adopted, that vehicular traffic should proceed at all times. This advantage was possessed, also, by several designs submitted, in which the roadway, at one or more points in the crossing, was divided into two branches, which came together again, embracing between them an opening for vessels, each branch being provided with its own lift-, draw-, or swing-bridge. The two branches, with the space enclosed between, thus constituted, in effect, a lock through which vessels could always pass, while at the same time one of the two branches of the roadway was always open for both pedestrians and vehicles.

MR. JOHNSON, acting secretary of the New Decimal Asssociation (London), issues a statement designed to bring home to the conservative mass of his fellow-countrymen (not to mention our own) the practical disadvantages of their refusal to adopt the metric system, as viewed from the stand-point of £. *s. d.* Hitherto the opponents of the metric system, while admitting that it may be all very pretty theoretically, have insisted strenuously upon the immense inconvenience and the enormous money loss that would be involved in its adoption, and the advocates of the system have seemed to acquiesce, to some extent, in the line of battle thus mapped out for them by the enemy, and to content themselves with enlarging upon the manifest advantages which the new system offers to the calculator; and it is therefore not altogether strange if the masses have come to regard the metric system as a costly scientific toy, which it was proposed to place in the hands of the scientists at the expense of the aforesaid masses. But Secretary Johnson quotes the latest report of the foreign office, to show that British trade fails, by reason of its adherence to the barbarities of the non-metric system, to obtain that foothold among foreign nations which it might otherwise enjoy. It is urged that the metric system is now employed, for instance, throughout Bulgaria, and that it is idle for English manufacturers to expect the Bulgarians to give themselves the trouble of learning the puzzling English weights and measures for the sake of sending their orders to English houses, while the representatives of more enlightened nations stand ready to treat with them in the rational system which they have adopted. British manufacturers, it is said, do indeed unbend to the extent of issuing their catalogues in the French or in other

foreign languages, but they continue to refuse to conform to metric measures. Such conformity must of course extend beyond the catalogues and must enter into their manufactures, and here, of course, is the rub; yet it can hardly be doubted that if our British cousins (again preserving silence respecting ourselves) can be shown that it will pay them to adopt the metric system, they may be induced to submit even to this innovation.

A correspondent who has occasion to ship from England to Peru, complains bitterly of the trouble to which he is put by being obliged to make out his shipping specifications twice over, first in English and then in metric weights and measures; but it is doubtful whether this appeal to the British humanitarian instinct will exert as potent an influence as that which the Secretary makes to the British pocket.

AT a recent meeting of the French Society of Civil Engineers a curiosity was presented in the shape of a pamphlet on compressed air, written a half-century ago by the late Tessié du Motay, and suggesting an infinite variety of applications of compressed air to a great number of industries, including a drawing of a locomotive operated by that means upon an ordinary railway in Paris in 1840.

AT the same meeting a paper was read describing the recent experiments of M. de Mas upon the resistance of boats to traction. These experiments have been in progress for about four years and have been confined thus far to cases where the cross-sectional area of the channel may be regarded as indefinitely great, relatively to that of the vessel passing through it. It was found that with a draught of 1.6 meters, velocity 1.5 meters, the addition of a strip of oil-cloth or wax cloth (*toile cirée*) 1.26 meters wide, resulted in a reduction of 13 per cent. in the force required for traction, while a coating of the same material, extending over the entire submerged surface, gave a reduction of 30 per cent. These results strikingly confirm the principle advanced by Darcy and Bazin, and elaborated by Ganguillet and Kutter, of the important influence exerted by the character of the wetted surface of a channel or pipe, upon the velocity of the water flowing through it; for the same principle of course applies equally, whether the water flows through the channel or whether the boat is drawn through the water. Enterprising boatmen recognize this to some extent, but it seems probable that very great economies might be effected by still further refinements in this respect.

Experiments at different velocities upon the resistance to traction exerted by vessels of different lengths indicated that the length of the vessel exerts very little if any influence upon the resistance, thus confirming the position maintained by Du Buat, who argued that the resistance due to the form of the vessel consists of two parts, namely, the head resistance, which is independent of the length, and the backward vacuum-like action at the stern, which is inversely as the length; that the friction of the sides is directly as the length, and hence that the total form resistance is independent of the length. M. de Mas, experimenting with spoon-shaped bows, resembling those of the American "whaleback," obtained by their use a reduction of 75 per cent. in the cost of traction; and in this he found his results confirmed by those of Klepsch, of Weimar, who has simultaneously been carrying on similar experiments. At this point M. L. de Chasseloup-Laubat, who will be agreeably remembered by those of our readers who had the pleasure of meeting the visiting engineers of the Société des Ingénieurs Civils de France in September last, remarked that he had found this spoon-shaped bow generally adopted in America and that its advantages were strikingly shown in the recent international yacht race between the *Vigilant* and the *Valkyrie*.

IN the matter of river-pollution Great Britain seems to hold the palm among civilized nations. The writer well remembers the condition of the Irwell at Manchester in 1889, at which time it was being subjected to the meliorating influences of Dr. Albert Leeds, of Hoboken, and is in-

clined to think that it threw even the shady Chicago river and the equally dark Gunner's run of Philadelphia into the shade. Glasgow has been awakening to the necessity of avoiding the pollution of the Clyde by her own offal, and has recently installed a sewage-purification plant draining an area of 2600 acres, with a population of 270,000. The works handle at present about 10,000,000 gallons daily, or about one-fifth of the total product of the city, and it is claimed that they are so arranged that their capacity can be easily and cheaply doubled. The system employed is that designed by Mr. G. V. Alsing, C. E., and successfully used at Sheffield. The works at Glasgow were executed under Mr. Alsing's charge. They occupy a site lying within a sharp bend in the river, and the sewage is brought to them through a 7-foot conduit. Solid matters suspended in the sewage are first removed by strainers consisting of endless vertical traveling screens arranged after the manner of link-belting, and the sewage then passes to two catch-pits, in the bottoms of which are V-shaped grooves provided with revolving conveyor-screws which force the remaining heavy matter to a sump, from which it is lifted by bucket elevators and deposited in cars. The sewage then flows to a well, from which it is lifted by four centrifugal pumps with a combined capacity of over one million gallons per hour, to a delivery main. It is then treated with lime and sulphate of ammonia, and passes through an open channel to the precipitation- and aëration-tanks and thence to the filters, from which it issues as "a perfectly clear and odorless liquid, devoid of all injurious properties," to the river. The filters are filled with coke, which, after it has become foul, is burned under the boilers. The sludge is treated with 1 per cent. of lime, to give it adhesion, and is then pressed into cakes by compressed air, and is used as a fertilizer on the farms recently purchased by the city for the purpose of raising fodder for the large number of horses used on the tramway system of the city, which becomes public property during the coming summer.

Thus does the massing of extended industries under the control of a single organization permit the application of reforms which otherwise would be impracticable. These works are practically completed. The total cost, including the 27 acres of land occupied, was $500,000, and the cost of operation will be about $50 per million gallons treated.

THE name of the microbe having become, in the popular ear, synonymous with sewage-pollution and with all the diseases which we naturally associate with it, it must occasion surprise to be told that the purification of sewage by filtration depends upon the action of beneficent microbes living and acting in the thin layer of slime which surrounds the sand-grains in the filter; yet such is the verdict of modern investigators. Of course, these benefactors, after they have done all they can for us, are ruthlessly destroyed, and their places taken by their successors; yet while they live and are permitted to work for us, they insist upon an adequate supply of oxygen for purposes of respiration. Mr. Sydney Richard Lowcock, Assoc. Mem. Ins. C. E., has recently been experimenting upon the effect of artificially supplying air to the sand used in filters, and has found that by such aëration the area of the filter-bed required for a given number of inhabitants may be reduced about 90 per cent. It will at once be seen that, if these results are borne out in practice, they must go far to extend the practice of sewage-filtration.

THE state of Massachusetts leads America in the matter of the study of water- and sewage-purification, and the reports of its board of health are recognized throughout the world as forming one of the most important sources of information in these matters. The board holds itself ready to give advice to those cities, towns, corporations, and individuals who apply to it for advice relative to systems of water-supply, drainage, and sewerage; and some seventy pages of the last report are made up of replies given by the board in response to such queries. The following extract from a reply given by the board to the Naukeag

Water Company, of Ashburnham, may serve to illustrate the character of the information conveyed:

The leakage from the reservoir at the present time permits a large amount of water to escape under the dam. This leakage should be prevented as far as practicable. It is probable, however, that a comparatively large amount of water will still flow out of the ground below the dam, so that the largest additional supply can be obtained by intercepting this water. Ditches extending out from both sides of the reservoir to intercept and divert into the reservoir the water which now flows past it on either side will also add to the supply.

This suggests the question: To what extent will the exercise of this beneficent office on the part of the state board conduce to the prosperity of the individual practising engineers of the commonwealth?

THE Massachusetts board investigates the character of the water-supplies and of the various river waters of the state, and compiles and publishes statistics regarding them. At the Lawrence Experiment Station (described by Mr. George W. Fuller in this Magazine for February) very important experiments upon the purification of sewage have been made. The writer has had the pleasure of spending an afternoon at this station, under the excellent guidance of Mr. Allen Hazen, the chemist-in-charge, who, in response to a request for a glass of water, filled a glass from a faucet and presented it as the effluent from the filters into which the town sewage was fed. It proved to be, so far as one could learn from observation and taste and from the absence of all unpleasant after-effects, a perfectly satisfactory drinking-water.

Mr. Hazen has been conducting some elaborate experiments upon the physical properties of sands and gravels, as related especially to their behavior as filtering materials. He finds that within certain limits of size of grain and of rate of flow the frictional resistance of sand to the flow of water through it varies directly as the rate of flow and as the depth of the sand (as stated in what is known as Darcy's law), with the temperature, being twice as great at the freezing-point as at summer-heat, and inversely as the square of the effective size of the sand grain, the "effective size" of a sand being that diameter below which one tenth (by weight) of all the grains are found. The friction, at the beginning of each experiment, is always higher than at later periods, because of the air in the sand, and this state of things does not disappear for several days. It is found that at a temperature of 10° C., and with an active head equal to the depth of sand, a sand whose effective size is 0.10 millimeter and whose pores are entirely filled with water and free from clogging, will pass 10 cubic meters of water per day for each square foot of sand surface. As already stated, the rate varies directly as the square of the effective size.

THOSE who had the pleasure of visiting the great exhibits of the Pennsylvania and Baltimore and Ohio railroads at Chicago last year will be gratified to learn that it has been arranged to place both of these exhibits in the Columbian Museum in that city, with Mr. J. Elfreth Watkins as director. Mr. Watkins, it will be remembered, was in charge of the Pennsylvania railroad exhibit. The Conductor understands that Major J. G. Pangborn, who similarly presided over the exhibit of the Baltimore and Ohio railroad, will make a tour of the world for the purpose of collecting other objects of interest, to be added to the collection.

THE Conductor finds himself incapable of excluding the following item from his train, even though his failure to do so may seem to smack of the shop. It comes from a correspondent in Honolulu and gives a conversation which is said to have taken place in Oakland, California:

WIFE (*to* GEORGE, *who is searching in his library*)—What are you looking for, George?

GEORGE—I'm looking for my "Trautwine."

WIFE (*misunderstanding*)—What on earth can you want with a trout-line at this time of night?

GEORGE (*ditto*)—I want a coefficient.

WIFE (*ditto*)—Want to go a-fishing? Who ever heard of *your* going fishing?

MECHANICAL ENGINEERING

Conducted by Henry Harrison Suplee.

THERE has been more or less discussion about the recent informal meetings of some of the members of the American Society of Mechanical Engineers at the rooms of the society, the impression being somehow current that they are meetings of the society itself, and that as such the papers and discussions should be included in the Transactions. It is satisfactory to see that such an interest is taken in these informal meetings, as the very tone of the criticism implies that the discussions are of sufficient value to make their permanent record desirable. But to insist that the meetings should be made "official" is as absurd as to object to the discussion of engineering topics by members in the rooms of the society at any time without the presence of a reporter and the publication of their words. It is true that the ripest experience of some of the ablest members of the society is often brought out in the course of a quiet conversation in an odd moment, without premeditation, and sometimes in the absence of those who would have been the most appreciative listeners; and one would often be glad to be able to turn to a report of some animated conversation which can be recalled in later days only as something to regret having forgotten. An informal meeting is nearly always the best kind of a gathering to develop the most valuable kind of professional conversation, and, while such meetings would lose their special value if they became official, it is the highest compliment which could be given to them to find absent members troubled when they discover the value of what they have missed.

The relations of such meetings to the regular conventions of the society may become somewhat like those of the *privat docent* of the German universities to the regular professor, the former being a sort of free-lance, lecturing on his own account to such students as choose to attend, but keeping the regular professor always on his mettle lest the irregular instructor be found so efficient and capable as to draw away his students and leave him addressing empty benches. If the informal meetings prove too attractive and their discussions more desirable than the regular Transactions, there must certainly be a friendly rivalry created between the active members at the unofficial meetings and the regular publication committee, which can result only in a most beneficial stimulus to the latter, spurring it to increased efficiency, with correspondingly more valuable results. There is ample room for both official and unofficial meetings, and it is a most encouraging sign of the energy of one of the most active of the great engineering societies that there should be just such lively interest and emulation.

ONE difficulty in securing papers of high practical value for the meetings of engineering societies lies in the fact that the very men from whom the most valuable material ought to be obtainable may not have the time to prepare papers or such facility in technical writing as to render the task an agreeable one. There is no doubt that very many of the papers presented before such organizations are the work of investigators and men of research rather than records of experience, although there are many purely practical contributions to be found in the pages of the transactions of all such societies. The portly volume containing the Transactions of the American Society of Mechanical Engineers for 1893, however, illustrates more than ever the fact that, notwithstanding the great value of the original papers presented, the

most interesting portions are the discussions which the papers elicit and stimulate. As the old Arab proverb has it, "the lesson is one, but the talk that follows the lesson is one thousand," and, either as a talk at the conventions or as a printed discussion appended in the completed record, there can be little doubt that the searcher after practical information from the practical men will turn with pleasure and profit to the discussions which add so much to the value of the book.

Not the least interesting of these discussions are those provoked, so to speak, by the "topical queries," which indeed often receive too little attention, though they rarely fail to elicit points of interest which, however familiar they may be to some of their hearers, are nearly always new to others. A man will always hesitate to attack or criticise a paper in writing unless he has had an opportunity to examine it carefully beforehand, while the verbal fencing by men who know whereof they speak often becomes vastly profitable and entertaining as well, one point suggesting another until one is surprised at the number of interesting features which an apparently simple query has developed.

THE contest which in earlier times existed between the man-at-arms and the knight on horseback, and which in modern days has been transferred to guns and ironclads, appears in another phase in the latest developments of attack and defense as existing between burglars and safe-makers, and as this branch of work, on the side of the defense at least, may properly be included as a division of mechanical engineering, no apology is needed for introducing it here. The appropriateness of including the subject of safe- and vault-construction in the scope of mechanical engineering is confirmed by the fact that the commission of experts appointed by the United States government to report as to means of improving the vault facilities of the treasury department was composed entirely of mechanical engineers,—namely, Professor R. H. Thurston, of Cornell; Mr. F. A. Pratt, of the Pratt & Whitney Co.; and Mr. Theodore N. Ely, of the Pennsylvania Railroad Co.,—and the report which this commission has just made to the secretary of the treasury is most interesting.

The commission visited the leading establishments in which such work is made, besides witnessing tests of the resistance (or lack of resistance, in most cases) of the various burglar-proof receptacles, and some of the results are anything but assuring to institutions hitherto supposed to be reasonably well-protected. There may be some consolation in the knowledge that probably Uncle Sam is worse off in this respect than almost any private establishment, but the only salvation for the treasury vaults at present appears to be the strong guards maintained there. Just now the makers of bank-locks appear to be ahead of the vault-builders, and what with the automatically operated bolt-devices, and beautifully constructed time-locks with all parts duplicated and many of them tripled and even quadrupled, the danger either of illicit entry or of accidental lock-out in connection with the locking devices is extremely remote. While the combination of layers of hard and soft steel, Franklinite, chilled cast-iron, and the like may offer many difficulties to the burglars in the limited time which is usually at their disposal, yet it is rather mortifying to read that any tests of such constructions to be of real value "must ultimately be finally made by experimenters of more experience, and professionally more expert than even the safe-makers"—*i. e.*, the burglars themselves—and that "experimental investigations of the vulnerability of such structures have been very seldom and very incompletely made—except by burglars." As a matter of fact these gentry have invariably shown themselves entitled to most respectful consideration as mechanical engineers, and the lock makers and vault-builders have scarcely been able to keep pace with them, even by the introduction of time-locks, automatic bolt devices, refractory materials, and the like; since the use of liquid explosives, blowpipes, special tools, and general ingenuity has constantly kept the defenders on the anxious bench.

It now looks as if the old story of the knight in his armor against the peasant with his musket was about to be repeated in this later struggle, and that heavy armor may be abandoned altogether in favor of alertness and watchfulness, assisted by all manner of electric alarms and guards. As speed is the all-important question in the modern cruiser, so prompt alarm is likely to be the main question in coming burglar-defense, and it may end in leaving the funds exposed to full view on a table which no man will dare approach, through fear of consequences which may be all the more terrifying because of their unknown character.

THE remarks of Engineer-in-Chief Melville, made at the recent annual meeting of the New England Society of Naval Engineers, and published in the issue of *The Engineer* (New York) of March 17, contain much that is of especial interest in view of the fact that the subject of premium allowances to contractors has been so freely discussed and criticised of late. It is not infrequently supposed that the premium system has caused many of the new warships to cost more than would have been the case had the premium system not been adopted, but Mr. Melville shows conclusively that such is not the case, and cites the fact that, when the proposals for the *Detroit*, the *Montgomery*, and the *Marblehead* were first sent out, the bids were all in excess of the appropriations, the required speed being 18 knots. When the speed limit was reduced to 17 knots, the reduction in the bids not only enabled the vessels to be built within the appropriation, but even allowed the premiums to be included, for a sum less than the original lowest bid when the speed was placed at 18 knots. Mr. Melville also referred to the article of Mr. McFarland in the February issue of THE ENGINEERING MAGAZINE, upon the new cruiser *Columbia*, and to the pleasure he felt at the great success which had attended the use of the system of triple-screw propellers which he had adopted for that vessel, against the advice and opinions of many men of much experience who were disposed to look upon the plan as largely experimental. In this connection he took occasion to refer in a most gratifying manner to the great value of the services of Mr. Mattice and also of Mr. Hollis, and it is indeed a reflection upon the policy of our navy department that it should not be able to keep men of such value, both to their chief and to the department, in the government service when private concerns compete for them. Some day the fact that the very best ability should always be retained at its full market value for the service of the nation may be recognized and accepted, but, as it now appears, no man of the highest ability can long afford to remain in the government service when there are so many prizes to be had in private practice. It has been said abroad that in America government engineers are permitted to talk much more freely than in England, for example, and that such freedom is far more for the good of the service than the enforced silence which obtains there; and when we compare the instructive and valuable talk of Chief-Engineer Melville with the curious manner in which Mr. Macfarlane Gray was forbidden to speak upon a purely mechanical subject involving no government information, at a recent meeting of the Institution of Mechanical Engineers, we must express our appreciation of the wisdom of the policy of our government in this respect.

THE interesting and timely article in the last issue of this Magazine by Mr. Frank Richards, entitled "Precautionary Hints to Inventors," suggests renewed attention to what is probably one of the most valuable departments of the venerable Franklin Institute of the State of Pennsylvania. The committee on science and the arts, a large standing committee of mechanical specialists, exists for the sole purpose of examining and reporting upon any inventions which may be submitted to it, with the added advantage of the power to recommend awards of the various medals in charge of the Institute, should the merits of the case warrant such action. It is not too much to say that the work of this committee has been of inestimable

value to those who have availed themselves of its services. When it is considered that it examines subjects with the same care as that given by expert specialists, making no charge for what otherwise would command a large fee, and that its approval or rejection is beyond criticism as regards prejudice or bias, the value of its services must be recognized. In many instances the unfavorable report of the committee has dissuaded either inventor or capitalist from certain loss or deception, while its approval and award in other instances has enabled financial assistance to be obtained, by sustaining claims which doubtless would have been received with incredulity if made upon the unsupported assertions of the enthusiastic inventor himself. Naturally such a committee is frequently called upon to examine subjects manifestly absurd in themselves and apparent as such upon inspection. While we believe that it has not yet followed the example of the French Academy in passing a resolution not to examine any new methods of squaring the circle, yet it undoubtedly reserves the privilege of rejecting such applications as are obviously unfit. At the same time, no one need hesitate to apply to the secretary of the Institute at Philadelphia to have his invention submitted for examination.

THE subject of synchronous vibrations is likely to receive more consideration in the future than it has in the past, since a thorough knowledge of all the elements which enter into this action may make it possible to reduce or possibly eliminate altogether the very objectionable vibrations which occur in steamships when the vibrations of the machinery are, so to speak, "in tune" with the hull. It is not unlike the old story of the fiddler who played the suspension bridge into a dangerous state of vibration; indeed, this principle obtains most practical recognition whenever a body of troops is ordered to break step when crossing a bridge. The excessive vibration which existed in one of the newer Atlantic liners was almost wholly removed by changing the speed of the engines, so that a cumulative vibration in the hull was no longer induced by the harmonizing strokes of the engines. A similar treatment might frequently be effective in cases where large buildings are found to vibrate to an undesirable extent by the action of heavy reciprocating machines, such as printing-presses and the like, and it seems possible that the use of some such instrument as Helmholtz's resonator might enable the "pitch" of a room, building, or even the hull of a vessel to be determined in advance to a sufficiently accurate degree to permit the speed of the machinery to be controlled beforehand, so as to reduce this reinforcement of vibrations to a minimum without involving radical changes after the entire plant is completed.

THE much discussed subject of transmission of power by belting is to have renewed attention given to it, under conditions that may yield a valuable addition to the present store of data, as a result of the proposed experimental investigations of the Société Industrielle du Nord de France in collaboration with the Institution of Mechanical Engineers. The latter society is to be represented by Professor Capper, of King's College, and the experiments, to be made at Lille, are to include a comparative investigation of the relative merits of ropes and belting for power-transmission. Accurate data upon this subject will be most welcome, as the present stock of information is hardly in a shape for satisfactory comparison, and more definite results should lead to a much wider use of rope-transmission if the proposed experiments confirm the conclusions derived from existing installations. It is to be hoped especially that these experiments will include comparative tests of the different systems of rope-transmission, such as the cyclic or reduplicated system already in extended use in the United States, as well as the so-called "ring" or circuit system introduced by Reuleaux, in which one endless rope traverses the entire circuit and returns to the primary source of motive-power. The advantages of these methods as compared with the use of a number of independent parallel ropes should appear in such a series of tests, as

well as the relative value of each system as compared with belting, and the character of the tests as well as the final results will be looked for with great interest.

WHILE coal continues to be used as fuel for the generation of steam and the consequent source of motive-power the subject of smoke-production and prevention will remain a matter of contention, unless the entire method of combustion and application be modified. It undoubtedly is true that effectual devices for the prevention of smoke from soft coal have been produced, but the fact that the advantages accruing from their use have not so far appeared sufficient to induce owners voluntarily to adopt them suggests the propriety of further discussion of this somewhat well-worn subject. As a matter of fact, the production of smoke by a boiler-furnace appears to be a natural protest on the part of both boiler and furnace against the unreasonably close proximity of the highly-heated products of combustion and the comparatively cool boiler-surfaces; and the production of smoke under these conditions is about as natural a result as is the production of fog when the warm, moisture-laden atmosphere of the Gulf stream meets the chilling influence of the Arctic current off the banks of Newfoundland.

It long has been known that complete and efficient combustion can be effected only in furnaces from which all chilling influences have been removed, and the universal acceptance by builders of metallurgical furnaces of the principles enunciated by Siemens should indicate the true lines upon which, not "smoke-prevention" but absence of smoke-production, should be worked out. The use of gas-producers and the methods of using producer-gas are surely well-enough known to bear wider application than has yet been given, and the present practice of firing each boiler independently is not much less primitive than would be the use of separate gas-retorts for the production of illuminating-gas for each establishment. The introduction of electrical methods of distribution of power would make it altogether possible to have power-generating plants placed entirely outside the limits of our large cities, and enable vast batteries of boilers to be fired with smokeless gas, generated from the lowest grades of coal in independent producers; while the power developed in engines of highest efficiency and transmitted and subdivided by electricity might almost rival in cheapness that which is to be obtained from Niagara. That such a plan contains some of the elements of experiment cannot be denied, but that the uncertainties either of cost or of construction are greater than those of the control of the great cataract may well be doubted; and the entire elimination of the smoke problem would be included as what might perhaps be termed a negative by-product.

AT a recent meeting of the Engineers' Club of Philadelphia, the subject of machine-riveting was discussed in a most interesting manner, the more so as the members from whose experience valuable data were obtained included Mr. James Christie, of the Pencoyd Iron Works; Mr. Wilfred Lewis, of William Sellers & Co.; and Mr. Samuel Vauclain, of the Baldwin Locomotive Works. As might have been expected, the pressure per square inch of rivet-section varied greatly, ranging from 30,000 to 150,000 pounds for hot-riveting, or as high as 300,000 pounds for cold-riveting. The main point appeared to be the attainment of as high a pressure as practicable without causing a tension in the metal of the plate about the rivet-hole exceeding the elastic limit of the material.

IT is one of the prerogatives of success to have its failures overshadowed by the brilliancy of its greater achievements, and this is sometimes a mistaken cause for discouragement to those who are still struggling. If we could know more of other men's failures we would be more lenient with ourselves at times, and it is well to remember the reply of a veteran engineer to a young man who was commenting on the wide range and success of James Watt: "He was indeed a wonderful man, but you must remember we cannot look over his scrap-heap!"

THE YOUNG MECHANIC

Conducted by Frank Richards.

THE Editor of THE ENGINEERING MAGAZINE asks "Who should have a place in it if not The Young Mechanic?" and echo promptly shouts "The Young Mechanic." That settles it, and here we are. The question had to come and there could be no other answer to it. You can't run a locomotive without steam. The age we live in can't run without the young mechanic, and why should the magazine of the age? The sharp, clear echo in answer is characteristic and might have been expected. Prompt and confident is the style of the time. For assuredly now is the youth of the world. Youthful it is in every characteristic and attribute and habit. Lord Bacon elaborated the idea that "we are the ancients," because we know it all. Though Lord Bacon lived in a slow age he was too fast. We don't know it all. We are learning now as never before, and doing more every day, and piling up treasures of knowledge and experience for the ancients who are still far in our rear.

Others, in their day, have variously characterized the age of the world. Here is John Alden and his fair bride, "Priscilla, the Puritan maiden," riding in state upon a white bull.

"Like a picture it seemed of the primitive, pastoral ages,
Fresh with the youth of the world—"

Fresh with the infancy of the world, rather. Only now it is that we come to the full swing of lusty and all-conquering youth. The true bridal chariot for John Alden's bride to-day would be a tandem bicycle. Soon it will be a locomotive bicycle. Bye and bye (who knows?) it will be a flying-machine and a honeymoon above the clouds. It is no more safe to prophesy; you can't shoot far enough.

In all seriousness, let us say that if ever on earth the young mechanic had a chance now is his time, if he be found ready and worthy. Doubtless there are always those to be found hanging around who whine and lament that they were born too late, that the deeds are all done. The deeds must have been finished very suddenly, then. We have only to take a glance backward. No matter how far we look we see the same thing. Take any time, ten years, twenty-five years, a hundred years, and the nearer the time the greater has been the proportionate progress. The nearer the now the higher the speed, and to-day is the swiftest of all. It is for us to jump on while we may, and it is not to be supposed that things will go any slower after we get aboard.

IT is anything but a discouraging state of affairs that we note as we look out on the business of life with a thought of taking a hand in it. The speed is not a thing to discourage us as long as we have the means of going as fast as the rest. Speaking about how fast the mechanical world has been going, who knows, for instance, that the steam-engine, that was finished long ago, has been improved more in the last twenty-five years than in the sixty or seventy years before it. A pound of coal for power is worth three or four times as much on a steamship now as it was "before the war." We know that the Corliss engine is more than forty years old, and the Corliss name is the siren strain that still beguiles the wandering customer, but the "Corliss" engine now is not the engine of forty years ago.

The field of the mechanic has widened in every direction. The whole line of electrical machinery has arisen like magic. The building trades have been transformed. The iron-manufacturer and the machinist now put up the building, and the stone-cutter and the bricklayer are the decorative artists to finish it. The machine-shop has been reconstructed upon the modern lines. It turns out more and better work

continually, but each shop has become a factory and each "machinist" is a specialist. The manual skill of the old chipper and filer is a story of a by-gone day.

"Not for this
Faint I, nor mourn nor murmur; other gifts
Have followed, for such loss, I would believe,
Abundant recompense."

So we could not very well be "catching on" at a better time, unless it were a later time, and we can't afford to wait. It cannot fail to impress any one who will give it a moment's thought that the audience to be addressed by this department is a much larger one now than it could have commanded in any earlier day. This is a mechanical age all through. The range of mechanical interests covers every occupation. Those not engaged in actual mechanical pursuits are still so related to them as to make it needful that they keep informed along mechanical lines. Any one, whatever his occupation, is in these times at a decided disadvantage if he has not more or less mechanical knowledge, and, without any possible limitation, we may say that the more he has the better. At one time we might have found ourselves addressing a class of machinist and blacksmith apprentices, with a few carpenters and pattern-makers; but to-day the young mechanic is almost anybody who is interested in anything. The applications of machinery and of the products of machinery and of the methods of machinery cover all industries and interests. If we can succeed in offering information or suggestion of value to any, we know that it must therefore be of value to the many.

IT may not be best to define very sharply what this department will undertake to do. Being assumed to be especially in sympathy with the hopes and aims of the young mechanic, it may find itself somewhat in the position in life of the young mechanic himself and have its course shaped more or less by the events of the time as they turn up, at the same time that it will be apt to do some of the turning-up for itself. If we get along as well as the young mechanic gets along in life we will have nothing to be ashamed of. When he first offers himself for a place where he may take hold and help to push along a little, the natural impulse and the general practice is to put him where he will do the least harm. Soon we find him making himself generally useful, then after awhile he becomes universally useful, and, before you know it, he is indispensable. We may hope to push the magazine along a little, and if, bye and bye, we find ourselves pulling it instead nobody will scold as long as everything goes. We hope to always respect the proprieties of the Magazine, but we may not forget that, to compensate for the ponderous dignity of the elephant, to him of all beasts it is permitted to wag his trunk as well as his tail.

As a dispenser of actual technical information we don't expect to figure very largely. If any dainty morsel come to our hand it shall go to swell the general store, but we must not be set up as a regularly-appointed caterer to the vast and clamorous call for mechanical provender. The whole of THE ENGINEERING MAGAZINE would not be large enough for a satisfactory exercise of that function. There be other storehouses vast enough, and filled with the riches of the fertile fields, and to them let any go that are in need. To the consummation of the most royal feast not the raw food alone is all that is needed. Right feeding is better than much feeding. We may perhaps help to prepare here and there a tempting dish of the materials that others have provided, but we shall remember always that, though the food be indispensable, so alike is appetite and digestion, and often the two latter are the more to be sought for and the more rarely found, and if we may help a little to stimulate the one or to promote the other we do exercise an office that is held among men to be more honorable, and more worthy of reward, than that of marketman or cook.

THIS winter has seen some brilliant and notable bicycle exhibitions. To these perhaps it may be attributed that we seem just now to have bicycle on the brain. Brain and bicycle are not a bad combination. Brain on the bicycle has done much for it.

The exhibitions spoken of must have opened the eyes of some of us to the rapid growth and the wide spread of the bicycle business, and when we remember how completely the bicycle belongs to the young, and especially to the young mechanic, it would have been a wonder if we had not been captivated, and if we had not been carried away an apology and an explanation would have been in order.

Who can realize how rapid has been the perfecting of the present bicycle? Who can realize for how short a time the present bicycle has been a possibility, not as an invention or, rather, a brilliant combination of inventions, but as a mechanical product? No matter how gifted an inventor may have been he would not have been able to produce the bicycle of to-day until to-day for lack of the material. The modern processes of steel production were to be invented with their means of cheaply, quickly, and accurately producing the precise metal for the special purpose, and always to be implicitly relied upon. How recent a production is the seamless steel tube that is literally, figuratively, and every way the backbone of the bicycle. It is said to be produced now by but two firms in the world and the process is supposed to be a secret, but there is little fear that the art of making it will ever be lost to the world. Yet the bicycle is entirely dependent upon this steel tubing for its present existence, and without this tubing an equally strong and trusty machine as the present could not be produced without adding a third to its weight; and lightness seems to be almost as necessary to a modern bicycle as to a balloon. And to-day we may seriously believe that the coming flying-machine is more likely to be evolved from the bicycle than from the balloon. Then, besides the special grades of steel for the several parts, and the wonderful tubing, a formidable line of special machinery and special processes of production have been devised in the interest of the bicycle, and these also have only been possible within a very few years. The perfect balls for the bearings are of quite recent growth; so also with regard to the chain, the pneumatic tires, and the others.

And, after all, the most striking thing about it is that we don't hear of any brilliant inventors that have done so many wonders in this one line. The fact is that so many have had a hand in it, each with his little suggestion, and here and there a more important one, that it has been impossible to particularize or to award special honors to any.

WE think that correspondence should be a valuable and attractive and helpful feature of this department. There are many things that we all want to know, and so many things that we don't know how to find out, and so many cases where we can help each other to find out and to spread the knowledge abroad. Then there are so many new things always coming up, and, other things being equal, anybody is as likely to strike them as anybody else, and if anybody does strike them everybody wants to hear of them, so please let us have them. Then a friendly word is a mighty power in the world, and of great help, to us young fellows especially; so if you have anything in that line don't hold it back and let it spoil. We will be glad to receive letters from any young person, not over ninety, upon any topic of interest to young mechanics. We think that on principle we ought not answer inquiries that do not provide for return postage. All other inquiries, not anonymous, will be answered, either by personal letter or through these pages. The identity of any writer will not be revealed unless permission is given.

IF we should seem sometimes to handle a correspondent roughly, no one is likely to get hurt. It will be only a playful shaking that will be good for his health. Now, here is a case. Some time ago "A Young Mechanic," so he signed himself, sent the following letter to one of the mechanical journals, and, curiously enough, we preserved it. "I like your paper," he says, "but I think it somewhat beyond the comprehension of young men such as I am. The illustrations of machinery and descriptions that do not name all the different parts are very hard

to understand. You had a compound engine in the other day that, without more specific explanations, was of no use to me. Many expressions which young mechanics do not understand, such as shearing strain, and the like, should, in our interest, be made plain by diagrams. I think it would assist the paper and make it much more popular among young subscribers if all these things were carefully explained in an elementary manner."

Now, all that reads very nicely. Probably the dear fellow really thinks that he and those that he speaks for are abused individuals. It is really a mild and gentle case of martyrdom from his standpoint. But what is it that he really asks for? He wants Shakespeare in words of one syllable. Isn't that about the size of it? If you want a colossal monument of impudence it takes ignorance to build it. God's universe itself is not written so that all its lore is open to the pupils of its primary department. Much is always still unknown to stimulate to farther study. A periodical can't always time its march to the step of its hindmost reader. If you want to keep up with the procession it will be well to step out lively.

It is no use expecting to have every road made dead smooth and level for us. We are lucky often if we can only find a steep and rocky footpath through the woods. We can't have everything as easy as rolling off a log, or we will do nothing better than rolling off of logs. The world or the shop or the magazine is not run exclusively in our individual interest. We must not ask to have every description and explanation set to our precise level; we must level ourselves up to it. We must not expect explanations to explain what is already sufficiently explained over and over again elsewhere. Nobody wants to be continually doing what is already well done. All draw the line somewhere; and generally somebody is left on the wrong side of it.

Now this scolding that we seem to be dealing out is not generally deserved, and is not warranted by the facts of the case; but it certainly is not meant as a scolding for anybody. If we should get up and give somebody a scolding once, the difference would be evident enough. The difficult thing is often enough evaded through other motives than either indolence or cowardice. It is oftener that it is not attempted because the difficult thing is mistakenly thought to be the impossible thing. Even in the way of learning what we should learn, we often don't do what we might because we don't know how to get at it. Right along here is where a little correspondence and a little comparing of ideas might help us.

HABIT and tradition should not dominate the thought of the young mechanic. The ideas of the old mechanics are being knocked into all sorts of shapes in these days. One of the odd fellows was at the bicycle-show and he saw a bicycle operated by a train of bevel gears that seemed to please him because, as he expressed it, it got rid of the "unmechanical" sprocket wheel and chain, you know. Bless his dear old heart. There is no such thing as an unmechanical device except the device that wont work as well as it might. We all know now that there is no such a thing as absolute dirt, that dirt is only matter where we don't want it, and so there is nothing that may be termed unmechanical if it is the best known means for a given purpose. The chain and sprocket wheel on the bicycle is no more an unmechanical device than the locomotive-piston or the wheels of a watch. The old steam-engine mechanic may see lots of "unmechanical devices" in successful operation. Agricultural machinery abounds in them. The electrical devices are many of them "unmechanical." The fishing-pole on the trolley-car is enough to make an old school mechanic either laugh or groan and gnash his teeth, according to the state of his digestion. It is all right to the young mechanic. To him there is nothing unmechanical if it works well, and if it cannot be improved upon. When our bicycles come to be all driven by toothed gearing it may be time to call the chain and sprocket wheel unmechanical, and not until then.

But the term unmechanical if used as a

reproach cuts deeper than it seems to. It does not apply so much to the specific device as to the whole machine. The whole bicycle might as well be condemned as unmechanical as to condemn the sprocket wheel and chain. The bicycle of to-day is really a marvel of mechanical invention and much more so of constructive skill. It is of exquisite material beautifully blended and highly successful for the purpose intended. In these days the terms successful and unmechanical are incompatible. Fine workmanship carefully adapted to its object is as evident in the bicycle as in the locomotive. Think of a complete bicycle with pneumatic tires and capable of carrying a man and weighing twelve pounds. We might well call it an impossibility if it were not a fact.

FROM Prof. Thurston's glowing paper in the World's Fair number of this Magazine the item that seems most particularly to cling to us is that every man, woman, and child in the United States "consumes" 300 pounds of iron per year. It is not to be supposed that this consumption is very evenly distributed, not as evenly as the consumption of the food products, for instance. Of course infants consume less than adults, and perhaps, though this is more doubtful, women less than men, and some men much less than others, so that it is pretty certain that some of us consume as much as a ton a year. And when we remember how slowly iron is dissipated and destroyed, principally by wear or by rust, we must all our lives be accumulating a stock of iron that is in constant use for us, and we practically own, without the trouble of looking after them, lengths of steel rails, bridge-girders, beams of buildings, telegraph wires, and such things, and our stock goes on increasing all our lives. We all die intestate as to this property, and it goes to our heirs, who are the whole human race. While we live we can't well help feeling some sense of proprietorship in the world. More and more we have things in common whether we would will it so or not. We shall leave a big stock of old iron to be carried along by those who come after us. All the iron that the centuries just ahead of us have left are a few rusty swords and some rattling suits of armor.

WE are jogging along toward the end of the century. No, it was the old family horse and "the one-horse shay" that used to do the jogging. What became of the poor old horse when the shay went to pieces, "all at once and nothing first"? At any rate he is dead and gone now, and there is no more jogging, or joggling either, as we are borne along. We fairly glide along now, and so smoothly that it is hard to realize how fast we go. Still we have more than six-years-and-a-half before the end of the century. If we are wrong in our arithmetic some one will please to kindly correct us. At the rate we are going, if the pace is to be kept up, or continually accelerated as it has been all along, the distance still to be covered is a vast one. We expect that the century milestone will be a blazing pillar of glory and gratulation, and all who stand around it may be proud enough if they may think that they have had a hand in its illumination. Only there will not be any standing around. We will go whirling by it like a meteor. None of the centuries that we read of have taken much notice of their completion; what are we going to do about ours?

CURRENT TECHNICAL LITERATURE

Conducted by Nelson W. Perry, E. M.

"THE IRON FOUNDER" SUPPLEMENT. A COMPLETE Illustrated Exposition of the Art of Casting in Iron. By Simpson Bolland, Practical Molder and Manager of Foundries; Author of the "Iron Founder," etc. Illustrated. New York: John Wiley & Sons. [Cloth, 12mo. 400 p. $2.50.]

IT has happened in the history of the world that some of the most ancient, as well as most useful, arts haev been very slowly influenced and modified in their methods of practice by accumulating facts of experimental science and by progress in other arts. Pottery, glass-making, and metal-founding may be cited as examples. Yet, recently, these have received a marked impulse from the advances of science and of sister arts. In particular, iron-founding, heretofore uncertain in its results, has awakened to the possibilities afforded by modern machinery, the light which chemistry has thrown upon the substances affecting the character of iron, the aids this science has placed at command of the founder, and the improvement in products attainable by a system of easily-performed physical tests.

The literature of the iron-founder's art, as compared with others of more recent birth, is yet meager, and any good contribution to it will be welcome to progressive foundrymen. Emphatically this may be predicted of any book carefully written by a master of both theory and practice, who fully recognizes that the art has not realized its possibilities, and is earnestly striving to bring about such a realization.

Such an author is Mr. Bolland. Readers of this Magazine will remember a well-written and very interesting article published in the issue of June, 1893, wherein, in addition to an entertaining historical sketch of the art, lines on which future progress may be reasonably expected were pointed out, and they will be prepared to find in the treatise above named an instructive and valuable book. In this expectation they will not be disappointed, though they might, from its title alone, which announces the work as a "*complete* exposition of the art," be somewhat misled as to the exact character of the treatise. The discrepancy apparent in the title is rendered still more so in the first paragraph of the preface, which sets forth, substantially, that the purpose of the book is to complete "The Iron Founder," a previous and meritorious treatise by the same author, which, however, deals so much with molding that the author himself says "it is to be considered a molder's book." From this paragraph the reader might naturally suppose that molding would not occupy so much of the text in the supplement as it really does; yet this involves no inconsistency, as the molding chiefly discussed in this book is quite out of the common run, or such as the author has chosen to style "high class." The founding of statues in iron and bronze is treated in an extremely interesting chapter, the description of processes being made so lucid that any intelligent person, though unfamiliar with metal-founding, may easily gain a clear idea of the methods employed. It is impossible, however, in the space allowed for this review, to convey an adequate impression of the book by an attempt to single out such specimens as this; the comprehensive treatment of the subjects "malleable-iron castings," the "theory and practice of chilling castings," as illustrated in the manufacture of car-wheels, and "case-hardening cast-iron," are all that will thus be mentioned specially.

A better idea of the scope of the treatise will be gained by the statement that, so far as concerns processes, those not usual in the common run of foundry-work are discussed and described; while, with reference to tools and appliances, the whole

field is exhaustively covered. What is said of pouring, flowing-off, and feeding cannot fail to be profitable reading to any iron-founder. If an expert, a perusal of this portion of the book will render more pronounced his estimate of the importance of care in the performance of this part of foundry-work, and, if yet a learner, he cannot afford to miss the opportunity of knowing what an able and experienced iron-founder has to say upon these subjects.

Probably most books offer a target for some criticism; and, after so warmly commending this book as a whole, it may be allowed to add that some pages near the end appear to be in the nature of padding, and that the index does not indicate as much painstaking as the general merit of the book deserves. Otherwise, it is a book containing up-to-date information indispensable to any iron-founder desirous of perfecting himself in his art, and valuable to all who are engaged in manufactures and constructive arts wherein cast-iron is an important material.

LEICESTER ALLEN.

ENGINEERING EDUCATION: BEING THE PROCEEDINGS OF Section E of the World's Engineering Congress held in Chicago, July 31-August 5, 1893. Published by the Society for the Promotion of Engineering Education as Volume I of their Proceedings. Edited by DeVolson Wood, Ira O. Baker, and J. B. Johnson. Columbia, Mo.: E. W. Stephens. [Cloth. 8vo. 342 p. $2.50.]

THERE has been no more disputed question of late than how can we best equip the young for the conflict with life in later years. These discussions hitherto have been carried on usually through articles contributed to the various magazines or technical journals, or forensically in the meetings of technical or educational associations of more or less limited scope. At Chicago, the assemblages of the various congresses were more cosmopolitan, and the diverse views arising from experiences under widely-varying environments were brought more closely into contrast with one another, than they had been on any previous occasion, and not infrequently the exponents of those diverse views were men whose reputations entitled them to the utmost respect. It is only by such exchange of ideas and their dispassionate discussion by competent champions that the greatest advances can be made. It was the cosmopolitan character of these assemblages that has given them their greatest importance, and the preservation in convenient form of the various ideas suggested for distribution and digestion at leisure among intelligent classes to which we must look for the production of the greatest amount of good as an ultimate result. The immediate result of the deliberations of Section E was the formation of a permanent organization for the promotion of engineering education, which has undertaken, as its first official step, the publication of the volume under review.

Those who are familiar with the subject know how great a revolution has taken place during the past twenty years in the ideas of what constitutes a liberal education. Scarcely two decades have passed since, by common consent, a liberal education, meaning by that a thoroughly classical course, was considered a prerequisite to the study of any of the learned professions. The former was considered a necessary preparation for the latter, and as a result the students in our professional schools were largely post-graduates. But the feeling gained ground rapidly that much of the time spent in this hitherto regarded preliminary course could be spent to much better advantage by devoting it at once to the study of those branches appertaining more directly to the profession in view. The pendulum swung the other way, and it is almost a rarity now to find a student in our technical schools who has completed an academical course in any of our reputable colleges. Then the question arose, and has been vigorously discussed, whether the manual training, field- or shop-practice should not even precede the attempt at mental instruction, whether the training of the hand should not precede the training of the mind, and, as a compromise, whether it would not be better that the two should go hand in hand. Educators are now beginning to realize that the pendulum has swung too far in this direction, and it is refreshing to note the tone of most of the

papers, which is unmistakably in favor of *breadth* of education rather than specific instruction.

The first paper in this volume is one entitled "The Ideal Engineering Education," by William H. Burr, professor of civil engineering at the Columbia School of Mines. The key-note of this paper is found in the following expressions: "By means of a liberal training, the requisite powers of observation and a sound judgment are more symmetrically developed and far more accurately applied in consequence of truer conceptions of the object on which they are brought to bear and a correspondingly enhanced power of healthy assimilation is acquired. The broad cultivation, it matters little when or where it is obtained, is the only effectual corrective for that narrow and malformed excellence in some special direction, which, while it is certainly much better than no excellence at all, falls lamentably short of the vigorous and well-rounded product of the ideal education in engineering. The writer unhesitatingly places, therefore, as the first and fundamental requisite in the ideal education of young engineers, *a broad, liberal education in philosophy and arts*."

Professor Palmer C. Ricketts, director of the Rensselaer Polytechnic Institute, in his paper on "Present Favorable and Unfavorable Tendencies in Engineering Education," expresses the unfavorable tendency of present methods, as follows: "It may be said in general that the engineer is not liberally educated. Beyond his profession his knowledge is not generally great. The writer believes the statement that the average man in any of the other professions is better informed on non-professional subjects to be a true one. The main reason is not hard to find. Very few of the young men entering our technical schools have had other than a rudimentary education. Very few indeed have had the advantage of an academic training. Their parents are too eager to get them at work. This is a mistake, and until the school of engineering is recognized as a post-graduate one it can hardly be expected that the engineer will take the rank among liberally-educated men to which his professional work justly entitles him."

George F. Swaine, professor of civil engineering in the Massachusetts Institute of Technology, in his "Comparison Between American and European Methods in Engineering Education," upheld what he called the American method for Americans and the continental method for Europeans. The former involved in its best form the co-education of the mind and hand, while the more characteristic feature of the latter was the great breadth of technical instruction given and the employment of the lecture system almost to the exclusion of the laboratory method. He held that the lecture system was only of advantage to students of more mature minds than the average of those entering our technical schools, and, while it might be an admirable method for Germany, for instance, was a failure here. In conclusion he says: "The principal improvement in technical instruction in this country, however, must be looked for through an improvement in the lower or preparatory schools, and a raising of the standard of training and knowledge required for admission to our higher technical schools."

In the discussion of this paper Professor John Goodman (Yorkshire College, England) took the ground that the continental methods were entirely too technical, and that for this reason they, in a measure, unfitted the student for practical work.

In the discussion of the paper on "The Hydraulic Laboratory of the Massachusetts Institute of Technology," by Professor Dwight Porter, Professor Goodman called attention to a proposition made by Professor Lanza that seems worthy of consideration on account of its novelty, viz.: that the work at the engineering laboratories throughout the world should be arranged similarly to that of the different astronomical observatories. He recommends that each college take up some special class of work and do it as thoroughly as possible, and communicate the results to the others. His idea is that every one associated would have the benefit not only of his own observations

and results but of those of the others. Such a plan would, of course, be entirely impracticable in our schools, although entirely practicable in institutions devoted to research only, the functions of the two being entirely different.

Some of the other papers read and discussed were on "Requirements in Mathematics for Engineering Education," by Professor Arthur N. Talbot, University of Illinois; "The Growth of American Mining Schools and their Relation to the Mining Industry," by Professor Samuel B. Christy, University of California; "The Equipment of Engineering Schools," by Professor Robert H. Thurston, Cornell University; "The Teaching of Graphical Methods in Engineering Colleges and Schools," by Professor H. S. Hele-Shaw, Harrison University College (Liverpool); "On Original Research by Students in Undergraduate Courses in Engineering, Especially Civil Engineering," by Professor Charles D. Marx, Leland Stanford Jr. University; "Training of Students in Technical Literary Work," by Professor Mansfield Merriman, Lehigh University; and "Methods of Studying Current Technical Literature," by Professor J. B. Johnson, Washington University (St. Louis).

We believe that this constitutes the most extensive symposium upon the subject of engineering education extant, and that it will furnish food for much thought among engineers in general and educators in particular.

A POCKET-BOOK OF MARINE ENGINEERING RULES AND TABLES: For the Use of Marine Engineers, Naval Architects, Designers, and Draughtsmen, Superintendents, and all Engaged in the Design and Construction of Marine Machinery, Naval and Mercantile. By A. E. Seaton and H. M. Rounthwaite. With Diagrams. London: Charles Griffin & Co; New York: D. Van Nostrand Co. [Leather. 16mo. 19-426 p. $3.]

SUCH a book has long been needed and desired by marine engineers, and the compilers of the above-named volume have shown an innate perception of what is likely to prove useful in a pocket-book for the use of this branch of the engineering profession. They certainly are unrivalled in the art of condensation. It would be difficult to suggest any topic connected with marine engineering concerning which this work supplies no information, and that in thorough shape and so arranged as to be easily found and not mixed up with general information. The excellent index at the end of the book adds to its utility. In a word, this is an exceedingly handy and efficient tool, possessed of which engineers will be saved many a wearisome calculation, or yet more wearisome hunt through various text-books and treatises. While they seem to have omitted nothing of special value to marine engineers, the compilers have avoided the introduction of extraneous matters, which would only make the volume bulky and its arrangement complex. It contains the most modern and approved practice. Steel has been dealt with as the material in general use and not an exceptional thing as heretofore, used only in high-class structures. The tables and weights, etc., are given fully for this material. Information and formulæ pertaining to light fast-running machinery has been elaborated and based on the most recent practice; also an excellent collection of data on screw propellers.

JOHN F. QUINN.

A TREATISE ON PUBLIC HEALTH AND ITS APPLICATION in Different European Countries. By Albert Palmberg, M.D. Translated from the French Edition and the Section on England Edited by Arthur Newsholme, M.D. London: Swan, Sonnenschein & Co.; New York: Macmillan & Co.

THIS translation of Dr. Palmberg's well-known treatise on public health may be heartily welcomed. It contains in succinct and compact form a resumé of the regulations affecting public health and sanitation in the chief countries and cities of Europe,—that is to say, in England, France, Belgium, Germany, Austria, Sweden, and Finland. It thus practically serves as a handbook to contemporary sanitary practice. The work has been prepared with the utmost care from extended personal researches; it has long enjoyed a European celebrity, and the present edition, which is the first in English, has been brought down closely to date. The book covers the widest range of topics, including everything that affects the public health and the sani-

tary conditions of living in city and country, from hospital regulations to those concerning buildings, from street-cleaning to the disposal of refuse. The subjects are treated briefly and concisely, as befits the wide range of topics and countries. Copious illustrations are used wherever needful. The longest section in the book is that devoted to England, which has been partly rewritten and wholly edited by Dr. Newsholme, the translator. This broader treatment of English sanitation was doubtless intended to make the book of greater immediate value to English readers, for whom the present translation was primarily designed. While not encroaching in any way upon the space devoted in the original to continental countries, it is perhaps to the latter rather than to the former that American readers will most incline. Some general review of comparative European sanitation has long been wanted in this country, and this want this book amply supplies. European countries, as a rule, go further in such matters than American communities have done, though the present tendency toward increasing the powers of our local boards of health and building departments is doing much to diminish this difference. Dr. Palmberg's work, if it has the circulation in America it unquestionably deserves, doubtless will do much to strengthen this tendency. We are glad to have an opportunity of heartily commending it, not only to the medical sanitarian, but to the lay reader whose familiarity with the questions treated in this book will add materially to the dissemination of correct knowledge on this most vital subject.

B. F.

ELEVENTH REPORT OF THE STATE MINERALOGIST, California State Mining Bureau (First Biennial), for the two years ending September 15, 1892. Sacramento: State Printing office. [Cloth. 8vo. 612 p., illustrations and maps.]

THIS report, in print, differs widely from its original shape. As first prepared there were 2307 pages of manuscript, containing duplications and much that was irrelevant, in the judgment of the board of examiners, who declined to publish it entire at the state's expense. The governor in a message criticised it severely, saying that "people will not read long, tedious reports." The legislature then referred the manuscript to a specially appointed editor, Mr. Charles G. Yale, with instructions to abridge and condense the manuscript. Although greatly cut down, with the omission of much of the purely scientific and descriptive text, it is still a bulky, rambling, and by no means satisfactory report; unsystematic and incomplete in essential points of information, while diffuse in matters of little public interest. There is unquestionably much good reading in the report (and this no doubt would be true of some of the parts suppressed) but it lacks the prime requisite of such a publication—a concise, intelligible, general review of the state's mining industry for the period to be covered. The fault is one too common in our national and state official reports, resulting from a misconception of their proper scope and function, compelling the reader to sift for himself out of a mass of information which he does not want that which he is seeking for, or omitting it altogether. This last California mining report is by no means bad of its kind; it is neatly gotten up, with some taking illustrations, and should be serviceable to those who have the time to read it. But the kind is not to be approved.

ALBERT WILLIAMS, JR.

NEW BOOKS OF THE MONTH.

Anderson, William.=On the Conversion of Heat into Work. A Practical Handbook on Heat-Engines. Third edition. (The Specialist's Series.) London. [Cloth. 12mo. $2.]

Ball, Sir Robert Stawell.=The Story of the Sun. New York: Appleton. [Cloth. 8vo. $5.]

Ball, W. W. Rouse.=Short Account of the History of Mathematics. Second edition. New York: D. Van Nostrand Co. [Cloth. 8vo. $3.25.]

Bloxham, C. L.=Laboratory Teaching, or Progressive Exercises in Practical Chemistry. Sixth edition. London. [Cloth. 12mo. $2.60.]

Blumer, H.=The Home Life of the Ancient Greeks. Agriculture, trade, handicraft, etc. From the German, by Alice Zimmern. Illustrated. New York: Cassell Publishing Co. [Cloth. 12mo. 563 p. $2.]

Box, T.=Practical Treatise on the Strength of Materials, Including their Elasticity and Resistance to Impact. Third edition. New York: Spon & Chamberlain. [Cloth. 8vo. 525 p. $7.25.]

Briggs, W., and Bryan, G. R.=Elements of Coördinate Geometry. Part I.—The Equations and Properties of the Right Line and Circle. London. [Cloth. 8vo. $1.40.]

Burn, R. S.=Illustrated Drawing-Book for the Use of Schools, Students, and Artisans. New edition. London. [Cloth. 8vo. $1.]

Cook, W. W.=A Treatise on Stock and Stockholders, Bonds, Mortgages, and General Corporation Law, as Applicable to Railroad, Banking, Manufacturing and Other Corporations. Third edition. Two volumes. Chicago: Callaghan & Co. [Sheep. 8vo. 4000 p. $12.50.]

Crowley, T. S =The Law of Strikes, Lockouts, and Labor Organizations. Washington: W. H. Lowdermilk & Co. [Cloth. 16 mo. 390 p 60 cents.]

Davis, J. P.=The Union Pacific Railway. A Study in Railway Politics, History, and Economics. Chicago: S C. Griggs & Co. [Cloth. 8vo 250 p., maps. $2.]

Demarest, T. F. C.—The Rise and Growth of Elevated Railroad Law. New York: Baker, Voorhis & Co. [Sheep. 8vo. 290 p. $3 50.]

Dickson, H. W.=Meteorology: The Elements of Weather and Climate. London. [Cloth. 8vo. $1.]

Donkin Bryan.=A Text-Book on Gas, Oil, and Air Engines: or Internal Combustion Motors without Boiler. London. 1894. [Cloth. 8vo. $6.50.]

Draper, C. H.=Heat and the Principles of Thermodynamics. With many illustrations and numerical examples. London. [Cloth. 8vo. $1.80.]

Foundations of the Molecular Theory: Papers and Extracts by John Dalton, Joseph Louis, Gay-Lussac, and Amadeo Avogadro, 1808–1811. (Alembic Club Reprints No. 4.) London. [Cloth. 8vo. 60 cents.]

Garnier, R. M.—History of the English Landed Interest, Its Customs, Laws, Agriculture. Vol. II. New York: Macmillan & Co. [Cloth. 8vo. 564 p. $3.50.]

Hickson, Sydney J.=The Fauna of the Deep Sea. (Modern Science Series, No. 60.) New York: Appleton. [Cloth. 9–169 p. $1.]

Hill, W.—The First Stages of the Tariff Policy of the United States. Baltimore: American Economic Association. [Paper. 8vo. 160 p. 15 cents.]

Holmes, G. K.—The Peons of the South. Philadelphia: American Academy of Political and Social Science. [Paper. 8vo. 140 p. 15 cents.]

James, C. A.—Mining Royalties. Their Practical Operation and Effect. New York: Longmans, Green & Co. [Cloth. 8vo. 280 p. $1.75.]

McCosh, James.=Philosophy of Reality: Should it be Favored by America? New York: Scribner. [Cloth. 8vo. 10–78 p. 75 cts., net.]

Pupin, M. I.=Thermodynamics of Reversible Cycles in Gases and Saturated Vapors: full synopsis of a ten weeks' undergraduate course of lectures. Arranged and edited by Max Osterberg. New York: Wiley & Sons. [Cloth. 4–114 p. $1.25.]

Suess, E.—The Future of Silver. Translated by R. Stein. Washington Government Printing Office. [Paper. 8vo. 105 p.]

Thrum, T. G.—Hawaiian Almanac and Annual. A handbook of information of value to merchants and others. Honolulu: T. G. Thrum. [Paper. 8vo. 162 p. $1.]

Vickerman, C.=Woollen Spinning: a textbook for students in technical schools, and for skillful, practical men in woolen mills. New York · Macmillan & Co. [Cloth. 12mo. 352 p. $1.75.]

Watson, E. P.—The Corliss Engine, by J. T. Henthorn, and Its Management, by C. D. Thurber. Third edition. With appendix by Emile Herter. Illustrated. New York: Spon & Chamberlain. [Cloth. 12mo. 96 p. 90 cents.]

Wheeler, W. H.—Tidal Rivers: Their Hydraulics, Navigation, Improvement. Illustrated. New York: Longmans, Green & Co. [Cloth. 8vo. 467 p. $5]

Wood, H. G.—A Treatise on the Law of Railroads. Three volumes. Boston: The Boston Book Co. [Sheep. 8vo. 6000 p. $18.]

NEW TRADE CATALOGUES.

Any of these catalogues free on application to the manufacturers.

The Jeffrey Manufacturing Co., No. 163 Washington Street, New York.=Elevating and Conveying Machinery; Chain Belting. 56 p. [Full-page illustrations of various types of links for chain-belting, with prices and details marked thereon, together with price-lists for types of chains not illustrated.]

The F. D. Cummer & Son Co., Cleveland, Ohio.=Drying-Machines for Ore-Roasters, Calcining-Machines, Hot-Air Furnaces, and Drying-Machines. 72 p. [Illustrated with cuts of leading types of drying apparatus and descriptive matter relating to the same. Especial attention is given to the methods employed by this company in preparing clays for the potter's and brickmaker's use and the mixing of ingredients for artificial cements.]

L. S. Starrett, Athol, Mass.=Catalogue and Price-List of Fine Mechanical Tools. 79 p. [In addition to the fine wood-cuts shown, intelligent descriptive paragraphs are copiously introduced. A new postal-insurance, covering all damage in transit to articles ordered by mail is explained.]

Harrison Brothers & Co., Philadelphia.=White Lead, Colors, Paints, and Chemicals. [Almost a manual of information on paints and pigments. Copious notes on the use of different paint materials; complete list of popular color names applicable to the numbers of the firm's "Town and Country" paints, in combination with sample cards of these colors; suggestions for harmonious and pleasing combinations. Pages are added on alum, acid, and other chemicals. Issued to commemorate the close of a century of business.]